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Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

JANUARY, 1945

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COVER

Portable Bailey Bridge Being Used in Italy. *Courtesy Hobart Brothers Company.*

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Subscription $5.00 per year in United States and possessions; Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York 18, N. Y.

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The Journal of
The American Welding Society
VOLUME 24 • NUMBER 1 • JANUARY, 1945

Jigs and Fixtures for Welding*

By A. N. Kugler†

MASS production methods, characteristic of American industry, have created certain requirements which must be fulfilled before a new manufacturing technique can qualify for use. Speed of production is perhaps one of the more obvious conditions to be met. This speed cannot be reduced to absolute numerical quantities but must be expressed in terms of increase over previous methods together with improvement in the product. Another essential, stated generally, is uniformity of product. This carries with it the corollary of dimensional accuracy which permits of interchangeability of parts. These must be achieved without increasing the unit costs. Other features such as simplification of operations, increased field of application or reduction in physical dimensions might be considered as requisite under some circumstances. However, such needs are really secondary to the first two named as for example, a simplification of procedure would hardly be acceptable if it resulted in less uniform parts.

Welding as a tool of modern manufacturing was early handicapped by its inability to fulfill these requirements. Witness the fact that the first applications of welding were in repair and maintenance operations. Such production operations as were employed were practically on a "tailor-made" basis. Not until welding was able to exceed the speed of other joining methods and assure uniformity of results, was it considered for mass production.

That welding today is a vital factor in wartime mass production will be borne out by a visit to almost any plant. This emergence into a position of prime importance is due to many factors including improvements in materials and equipment. High in this group of contributing factors has been the gradual evolvement of devices for facilitating and speeding welding and at the same time insuring uniformity of finished parts. The terms "jigs" and "fixtures" used to designate these devices were borrowed from the machine tool industry.

The *Welding Handbook* (1942 edition) has devoted Chapter 32A to this topic. In this chapter an attempt is made to define the terms "jig" and "fixture" on the same basis used in machine tool practice. Unfortunately, however, this is unsatisfactory for the reason that the functions performed are not identical. Thus, while the names jigs and fixtures have been appropriated from the tool engineer, the ultimate use is appreciably different.

Jigs and fixtures for welding may be used to position the work piece for flat or down-hand welding. Welding in this position proceeds at highest speeds and yields the best mechanical properties. Additionally, these devices may be used for locating units of an assembly in proper relation, one to the other. Obviously, under some circumstances, these two functions may be combined in one device. Of more recent evolution, particularly in connection with war production, has been the development of indexing fixtures and holding devices for machine gas cutting.

The design of jigs and fixtures cannot be reduced to mathematical formulas such as are employed for example, in the design of building structures. The ultimate form of any jig is usually the result of careful study of the requirements of the job plus a liberal application of imagination. No two designers presented with the same problem would arrive at the same solution. The development of this type of equipment provides an exceptional opportunity for free play of ingenuity. In fact, it might be said that jigs and fixtures as currently used, are typical products of American inventiveness. Certainly the examples found in shops today run the gamut of crude makeshifts to elaborate precision tools. Aside from desirability for fine workmanship and good equipment, it matters little how the jig is finished as long as it performs its function efficiently.

While it may not be possible to provide elaborate and definite rules for designing this equipment, still certain principles must be observed to insure success. Thus it should be rather obvious that jigs and fixtures should be as simple as is consistent with the requirements of the problem. Complicated units may be a joy to the gadgeteer but are definitely a handicap to the man in the shop. Additionally, these jigs should be rugged and substantial without being excessively heavy. They must be strong enough to hold the component parts in the desired positions not only when cold but also when heat of welding is applied. If a member of a jig springs or warps, it is not fulfilling one of its fundamental functions, namely, insurance of accuracy. Finally, such holding devices as may be employed should be quick and easy acting. Threaded clamp screws, while effective for holding parts, are generally too slow in operation for most jig work Far better for this function are the eccentric or toggle

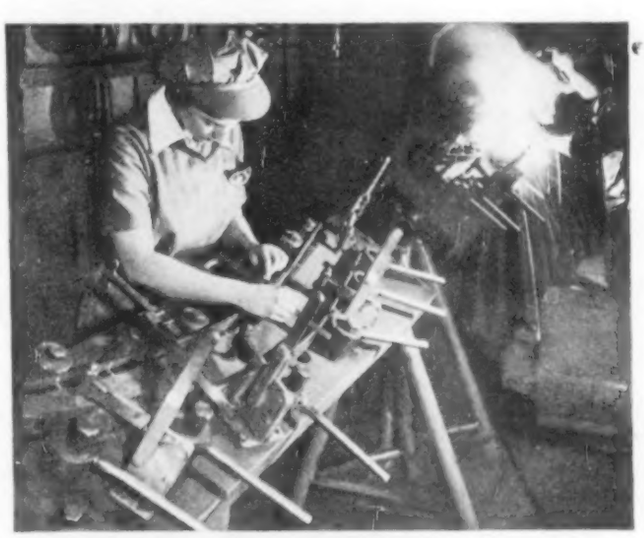

Fig. 1—Jig for Assembling and Tacking Parts for a Curved I Section. Eccentric and Toggle Clamps Are Fast Acting. Jig Bed Rotates on Trunnions to Permit Tacking of Underside Through Holes in the Bed

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio. Oct. 16 to 19, 1944.
† Mechanical Engineer, Applied Engineering Dept., Air Reduction Sales Co.

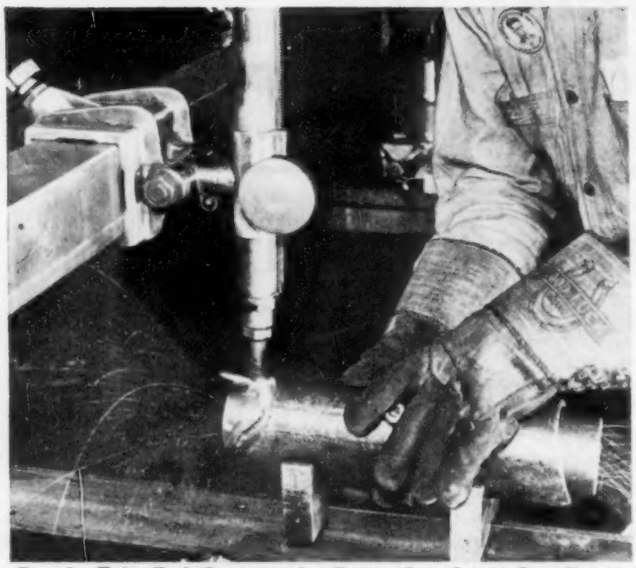

Fig. 2—Tube-End Contours for Fitting Into Joints Are Cut to Shape by Clamping the Tube Inside a Sleeve and Riding the Cutting Tip Against Shaped End of Sleeve

clamps which may be made up from standard material available or may be purchased in a variety of sizes and shapes for assembling into jigs. It has always been a fundamental principle in machine design that the best design is that which approaches and solves the problem with the utmost directness and simplicity; this is equally true in the design of jigs and fixtures for welding.

Since the design of jigs and fixtures must be considered as largely empirical, it follows that one of the best means of considering this problem is to study the successful work of others. Having analyzed such devices as are performing satisfactorily in production, one can then borrow such features as suit the particular need in designing other equipment. To assist those who must design this equipment a group of jigs and fixtures currently in use has been assembled for consideration. Therefore this paper is in the nature of a progress report supplementing the data published in the *Handbook*. It has been largely selected from war production, using such items as are available.

Fig. 3—This Simple Welding Positioner Holds Tacked I Sections in Position for Deep Fillet Welding in Down-hand Position

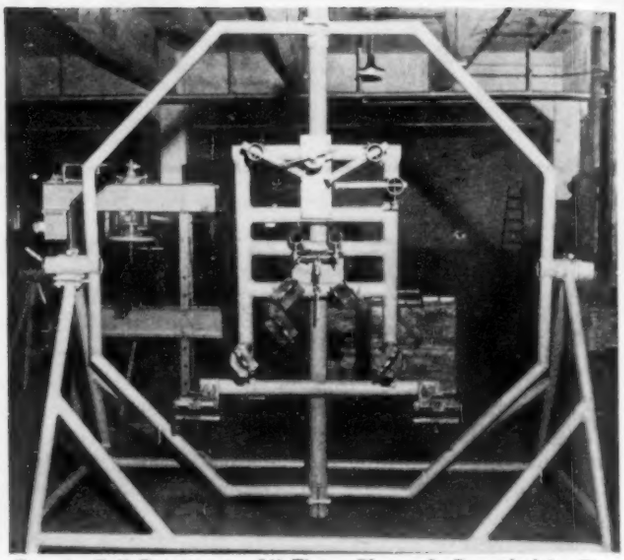

Fig. 4—Full Rotation in All Three Planes Is Provided by This Assembling and Tacking Jig, Which Has Locators for Tubes and Other Sections of Aircraft Beaching Gear

The aircraft industry has been one of the pioneers in the use of welded jigs and fixtures not only for welded fabrication but also for riveted assemblies and machine tool operations. In the first group of jigs and fixtures to be studied we have a series of units designed to facilitate the fabrication of subassemblies for the final assembly of beaching gear. Beaching gear is that equipment which is attached to seaplanes to assist in bringing them onto land for maintenance work. Figure 1 illustrates one of the initial subassembly steps in bringing together the component parts of one arm of the beaching gear. This unit is in the cross section of an I of varying web depth and curved shape. It is therefore fabricated of three steel plates, cut by an Oxygraph to form the web and flanges of the unit. The flange elements are roughly preformed in bending rolls. In this jig the elements are positioned in proper relation to one another with suitable locators to insure correct alignment. Observe the use of toggle hold-down clamps for holding the web section in the correct position. Also note the use of eccentric clamps for holding the curved flange sections in intimate contact with the web. Following correct alignment in these jigs, the elements are tack welded by the operator who may be seen working on the jigs in the background.

Fig. 5—After Being Tacked on the Jig in Fig. 4, Beaching Gear Are Fully Welded on This Positioner, Which Is Designed for Rotation in Any Plane

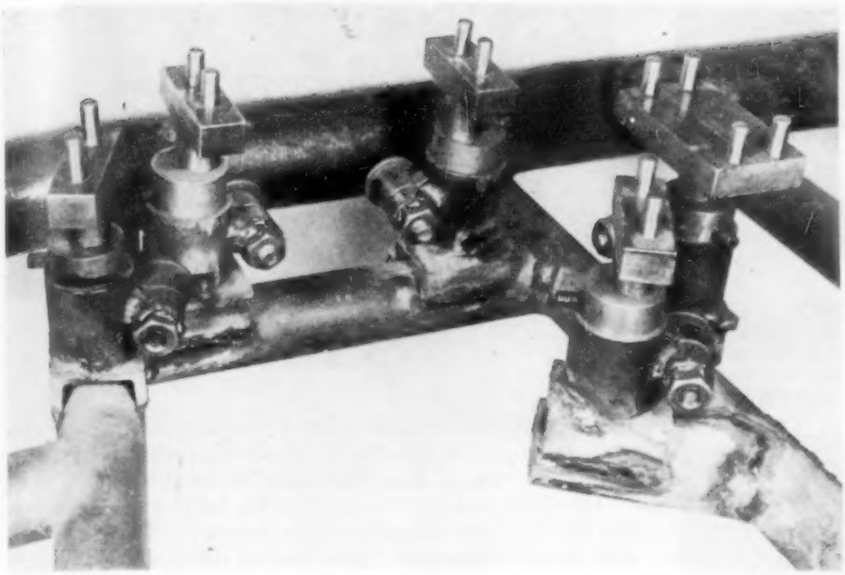

Fig. 6—Adjustable Locators Welded to Frame of Jig to Hold Elements of Tubular Assembly in Position During Welding. Both Lateral and Vertical Adjustments Can Be Made

while the long sweeping arms are handled by the locators seen near the tube. This jig is used merely for tack welding of the elements into final form. Observe that this jig permits 360° rotation in two planes.

In Fig. 5 is pictured another jig of substantially the same design as that shown in Fig. 4 but in this case employed for the final welding of one of these beaching gear. In this phase of the work the flexibility of this jig design is quite evident since the operator can position the assembly at virtually any angle to facilitate its welding. The general outline of the beaching gear becomes more apparent when this view is studied.

One of the most outstanding examples of resourceful jig design in the aircraft industry was brought about by a very critical delivery condition. A contractor was required to design jigs to tool up for a very complicated fuselage assembly. This involved some 200 separate tubular members ranging from $^3/_8$ in. round to $1^1/_2$ in. square, encompassing virtually all sizes and weights in between, together with 150 separate fittings. In addition to this, the structure was not symmetrical, which contributed additional problems in the form of shrinkage and locked-up stresses. Several of the trusses forming this fuselage were not simple plane elements but rather assemblies of tubes in several planes. The fact that this problem was successfully "licked" within the short period of 60 days is ample evidence of the skill of the tool designers working on the program. The means which they employed for this phenomenal success will prove of great assistance to others confronted with a similar prob-

Another element of this beaching gear design is a tubular cross brace. In order to fit these tubes to one another it is necessary to cut the correct intersection curves. In Fig. 2 is illustrated an ingenious device for performing this operation. As here illustrated it is being done using one of the standard machine cutting torches attached to a large cutting machine. However, this need not have been employed here since any cutting torch fastened rigidly would have done the same work. In effect, the device positions the tube to be cut inside a large tube by means of set screws, one of which may be seen under the operator's left hand. This larger tube is free to revolve in a pair of V blocks. A simple roller is slipped over the cutting tip and spaces the cutting jet at the right point for the cut. Note that the contour of the cut is controlled by the shape of the end of the external holding tube. In operation once the cut is started the operator merely rotates the external tube, making certain that the roller is in constant contact with the prepared curve.

The subassembly which was illustrated in Fig. 1 is now shown in Fig. 3 in position for welding. One of the functions of jigs and fixtures for welding is that of positioning the work for fastest welding and at the same time, insuring quality. Recent developments along these lines have led to the procedure known as deep fillet welding. The advantages of this technique are doubtless familiar to all. However, to attain these advantages it is necessary that the part be held in either the flat or horizontal positions. The jig illustrated in Fig. 3 performs just that function. A simple clamp grips one of the flanges while two shafts at right angles to each other permit ready positioning to facilitate welding with the E6020 electrode using the deep fillet technique.

With the completion of the several subassemblies these units are next brought to the final assembly jig pictured in Fig. 4. The tubular cross brace is accommodated at the lower portion of the central element

Fig. 7—Two Swinging Jigs Enable One Girl at Lower Right to Assemble and Flux Canteens for Two Welders

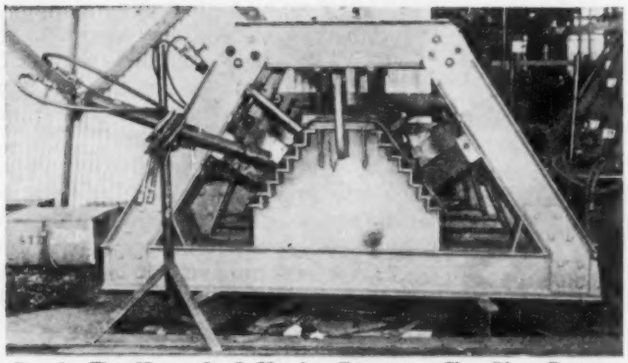

Fig. 8—This Heavy Jig Is Used in Forming a Ship Plate Section to the Outer Contour of the Central, Stepped Mold

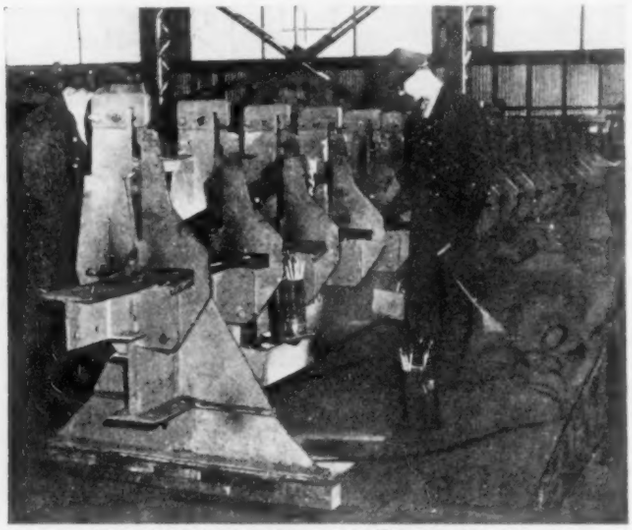

Fig. 9—Note the Effective Clamps in This Jig, Used for Assembling Ship's Deck Girders

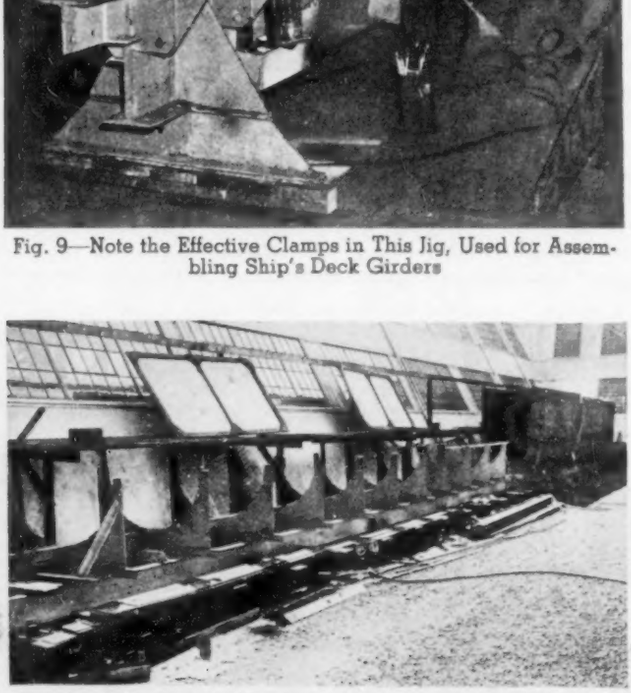

Fig. 10—This Lengthy Jig Facilitates Assembly and Welding of Shaft Alley Tunnels for Merchant Ships. Partially Completed Tunnel Can Be Seen in Rear

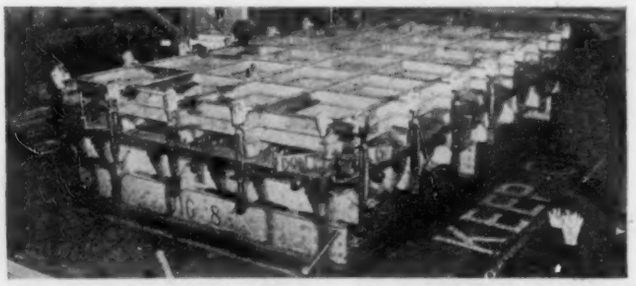

Fig. 11—This Hatch Cover Assembly and Tack Welding Jig Employs a Massive Top Composed of I-Beams to Maintain Rigidity. Careful Engineering and Labor Spent in Jig Construction Is Rewarded in Speedier Fabrication

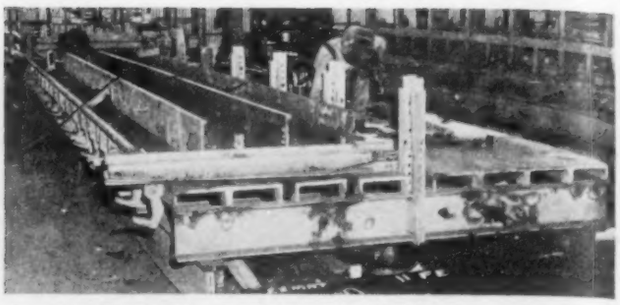

Fig. 12—Hatch Side Girders and Hatch End Beams Are Made on This Heavy Jig

lem. A complete description of these jigs is furnished in an interesting article by J. W. Clerke, appearing in the July 1944 issue of THE WELDING JOURNAL.

The first problem was to devise locators for positioning the tubular elements of the trusses. Two such locators were developed. The first is illustrated in Fig. 6. It consists of a split tube with a bolt clamp. Inserted within this tube is a bar into which is drilled an eccentric hole. Fitted into the eccentric hole is a smaller bar topped with a block upon which are mounted pins spaced apart a distance equal to the diameter or size of the tube. It will be observed that by providing the eccentric location of the small bar with respect to the large bar a means for lateral adjustment is provided. In practical operation this permits of placement of these locators in approximate position and final adjustment in accurate position later when conditions have been set up as desired. This lateral adjustment is obtained by merely rotating the large bar within the split clamp. The eccentricity of the small bar provides the lateral movement. With this adjustment available, the mounting of these locators in position on the jig frame requires no great precision; a tolerance of $\pm 1/8$ in. is sufficient.

This same locator has an additional adjustment vertically. This is achieved through set screws which hold the small bar within the large bar. By loosening the set screws, the block and pins may be raised or lowered to the desired elevation. From this it will be seen that this eccentric locator provides adjustment in two planes over

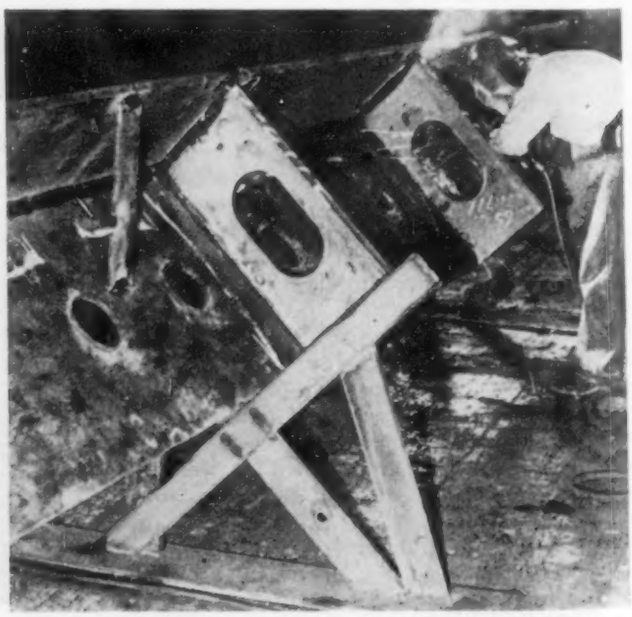

Fig. 13—The Familiar V-Block Is Here Adapted on a Large Scale for Use as a Positioner for Large Weldments

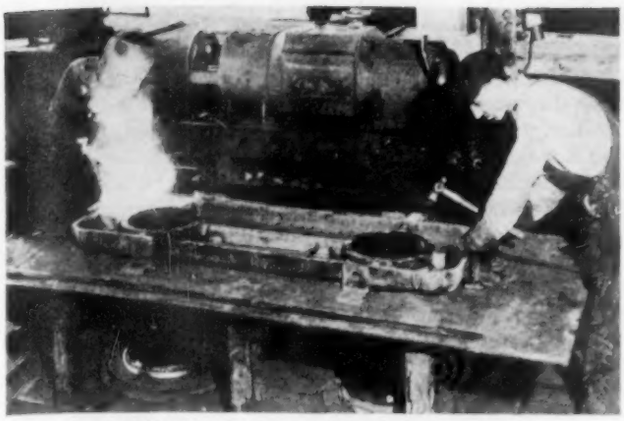

Fig. 14—Both Tacking and Final Welding of a Ship's Mooring Bitt Are Done on This Simple Jig

a reasonable range. This in itself is distinctly helpful since the elements may be positioned rapidly without consideration for shrinkage and distortion. Subsequently, in welding the first piece, such adjustments as may be indicated are made and the locators fastened, giving a jig which will result in uniform products.

Obviously the eccentric locator requires some fine machine work and fairly extensive machine shop facilities. A simpler locator which may be fabricated with less elaborate equipment (in fact, an ordinary drill press is all that is required) was also developed. It consists essentially of a channel section welded to a $^1/_2$-in. bolt or headless set screw. For lateral adjustment, two set screws are threaded through the legs of the channel into nuts welded at the outside. For vertical adjustment the jig frame is drilled with a hole large enough to accept the $^1/_2$-in. bolt. Over this a nut is fitted into which the $^1/_2$-in. bolt is screwed and held into position by a back-up bolt. When final position of the several elements is established, small tack welds are made on the several bolts and nuts to assure maintenance of alignment and position.

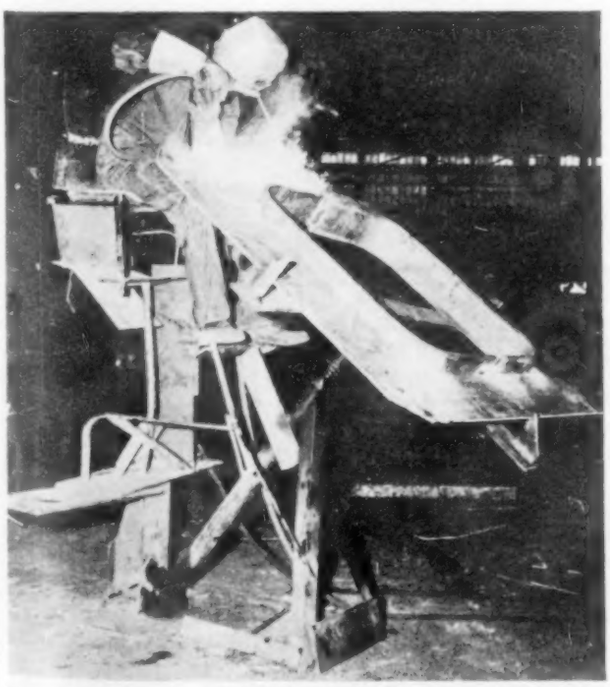

Fig. 15—This Shop-Built Welding Positioner Supports Both Weldment and Welder in Convenient Working Position

An additional feature of this locator is a spring-loaded clamp for holding the tubing within the jig. This element is merely welded to the jig frame at the desired position. This type of locator is used particularly on lighter assemblies and at points where the size and complexity of the eccentric locators preclude their use.

As ingenious as these locators are, this story would not be complete without referring to the means for assembling these devices on the final jig frames. It will be recalled that it was stated that the trusses involved in this particular structure were not simple plane trusses but rather complicated assemblies in several planes. Had the usual method of jig fabrication been employed, weeks and even months might have been consumed in

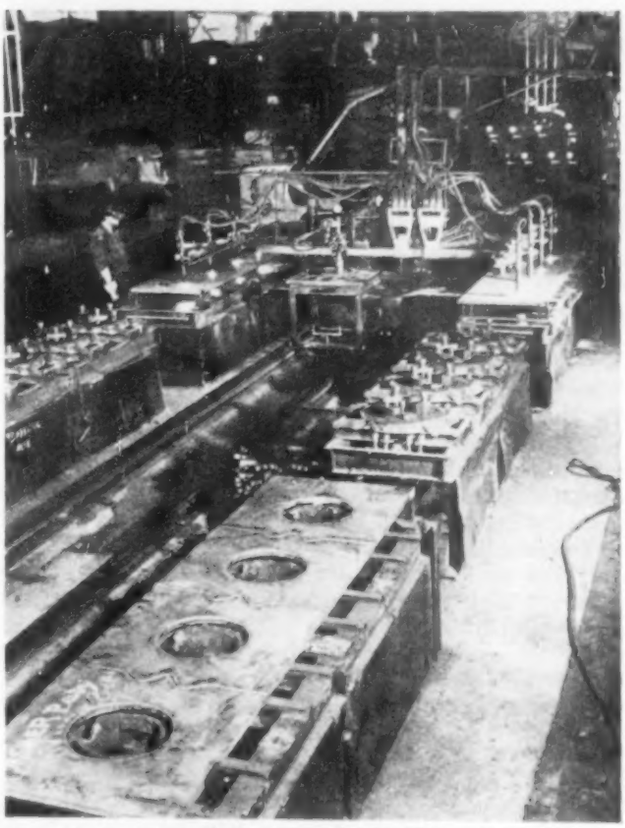

Fig. 16—Six Cutting Tables Are Used in Pairs in Sequence in This Setup for Production Cutting of Tank Sprockets. Template Table Rolls on Tracks Behind Travograph, Is Locked in Place at Each Working Position

assembling the necessary jigs and fixtures. To expedite this phase of it, a procedure known as 3-dimensional lofting was employed. In this, the plan view of a truss or subassembly is laid out to full scale on a heavy plywood board. On this is built up wood strips of dimensions equal to the tube elements to be employed in the subassembly. For a simple assembly lying in one plane, this pattern represents strips all of one height. If, however, a more complicated multiplane truss is involved, then it becomes necessary to provide strips of varying depth. These depths are secured by selecting a suitable datum plane and measuring the vertical distances from that plane to points on the truss. Utilization of these molds frees the jig designers and jig fabricators for more important work since carpenters can do this class of work. Once the molds are completed and checked for accuracy, then appropriate locators are placed upon the wooden projections, two each being supplied for each section of tube. Following this, the heavier pipe elements of the jig frame are applied to the locators and

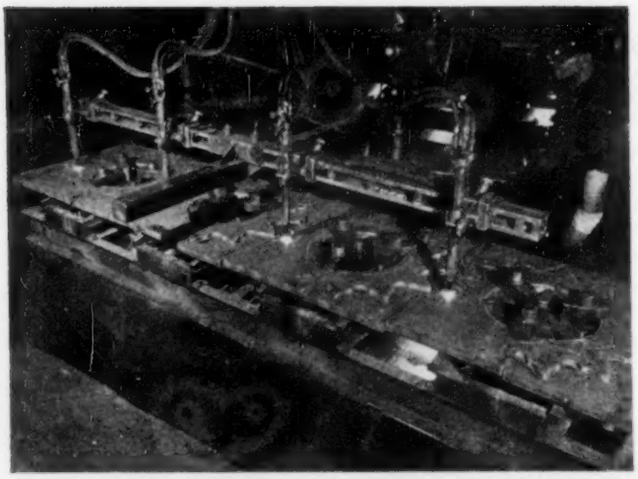

Fig. 17—Close-up of One of the Two 4-Torch Cross Bars Mounted on Travograph Torch Bar. Central Clamping of Work Pieces Reduces Creep and Promotes Extremely Accurate Cutting

tack welded. Subsequently, the welding is completed. Since each of the types of locators described permits of adjustment, any minor errors may be corrected and such provisions for expansion and contraction as may be necessary are cared for.

By this exceedingly ingenious method of 3-dimensional lofting coupled with adjustable locators, this particular contractor was able to tool up for this very complicated job in the remarkably short space of 60 days.

While the application of jigs and fixtures to aircraft assemblies is impressive, particularly from the angle of the high degree of accuracy secured, other applications are equally interesting. For example, in the assembly of the simple canteen used by the soldiers for drinking water, jigs and fixtures are vitally essential in order to insure a high rate of production. The jigs involved in this work are quite simple yet perform so well that one might consider them the whole key to success in this manufacturing operation. (See article by W. F. Lautner published in the July 1944 issue of THE WELDING JOURNAL.) The familiar shaped canteen is made in two halves as stampings. To join these two halves the edges of the aluminum stampings are flanged in amount about equal to the thickness of the material, these flanges being formed in the stamping operation. The flanges on the two parts will be aligned, and fused with a welding torch to effect the connection of the component elements; therefore no separate welding rod is needed. Since this is an aluminum welding job, parts must be fluxed after cleaning and before welding.

Time studies of this work indicated that one operator could do the fluxing and assembling for two welding operators. Therefore, a double-ended jig as shown in Fig. 7 was provided and two of these jigs were placed close to one another. The girl on the right assembles the parts and applies the flux, performing this operation for the two welding operators shown to the left and rear. When either welding operator has completed the welding on a canteen she rotates the jig about a central shaft, thus bringing the newly fluxed assembly into position to be welded. The fluxing operator removes the welded canteen and repeats the procedure.

Details of the features of the jig in so far as positioning the canteen for welding is concerned may be seen in Fig. 7. It consists simply of a turntable that is operated by hand by the welding operator. The work platform of this turntable serves to hold and position the lower stamping while the upper portion of the jig holds the upper stamping in proper alignment and intimate contact with the lower half. Since no welding rod is employed, the operator's left hand is free to turn the jig while she applies the welding torch to the flanged edge seam.

The importance of welding to shipbuilding is common knowledge. In fact, it might be said that this wartime program has been largely responsible for the public's knowledge of the process. The requirements for ships have been prodigious and to meet these needs, mass production procedures had to be employed. Since welding is essential to the rapid production of ships, it follows that jigs and fixtures have played an important part. One shipbuilder is even employing a jig which holds and rotates a whole ship of relatively small size during its final fabrication operations. While no photograph of

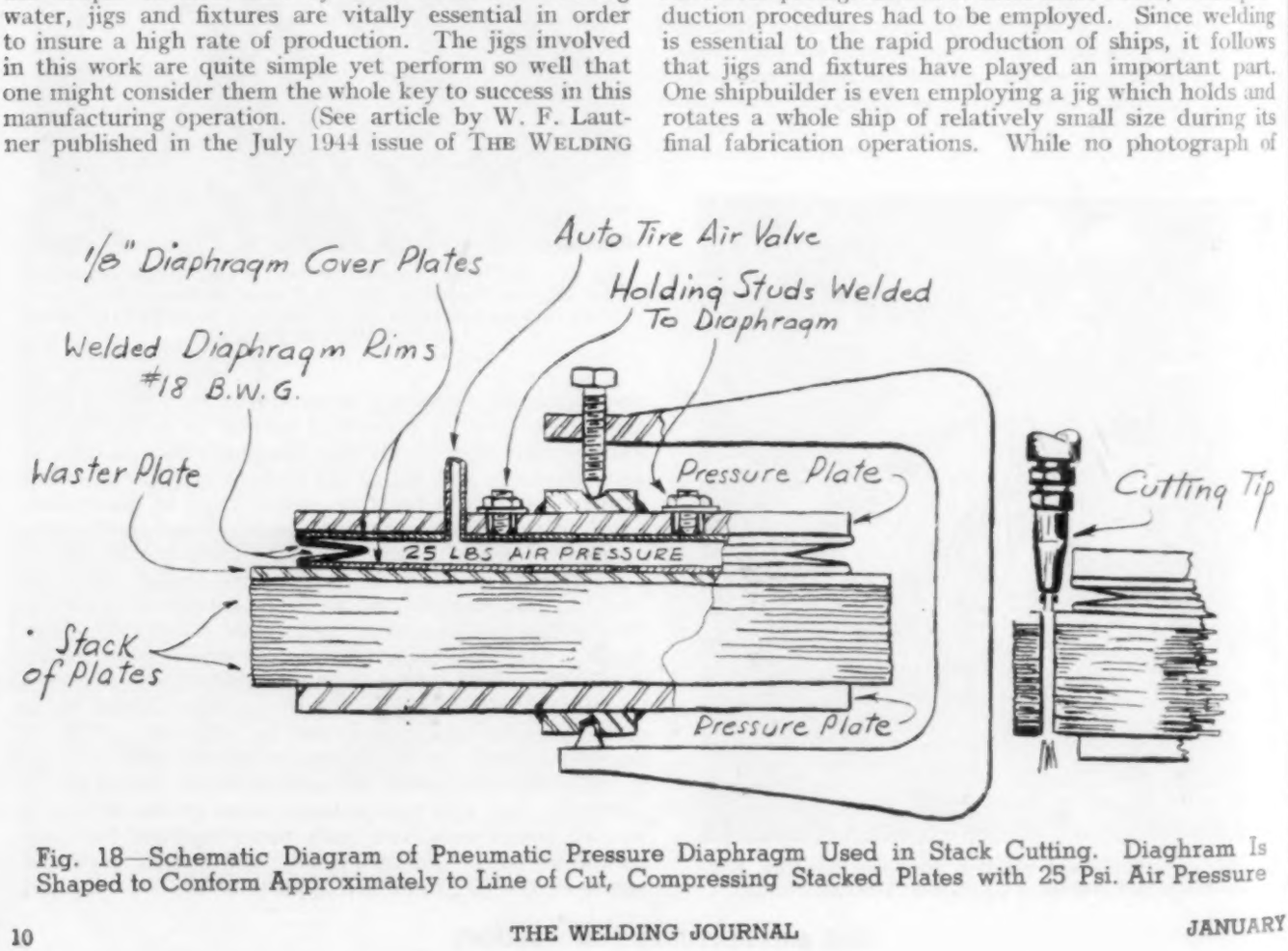

Fig. 18—Schematic Diagram of Pneumatic Pressure Diaphragm Used in Stack Cutting. Diaghram Is Shaped to Conform Approximately to Line of Cut, Compressing Stacked Plates with 25 Psi. Air Pressure

this is available, it has been frequently illustrated in the technical press and is doubtless familiar to all.

Less spectacular, but none the less important are the host of jigs for subassemblies. In many cases great ingenuity has been exercised in developing these. For example, Fig. 8 shows a jig for molding "furnaced" bottom shell keel plate to fit the stern frame casting. Note how the positions of the flat faces are maintained without abstracting too much heat, by using a stepped contact arrangement. Observe the heavy clamp at the end. This jig is obviously well designed to perform a very heavy fetting function.

Figure 9 represents many excellent principles in jig design. The jig is employed for the assembling of deck girders for such functions as hatch side girders and hatch end beams. The "T" section serves to locate the horizontal element while the massive, yet novel, clamps locate and hold the vertical member. The method of clearing around the horizontal projection is well executed.

A jig for positioning elements in proper location, and subassemblies in correct relation to one another, is shown in Fig. 10. This is employed for assembling the component parts of the shaft tunnel which runs from the after engine room bulkhead aft to the stern tube and houses the shaft. Completed elements may be seen toward the rear.

An excellent example of a massive jig designed for fitting, assembling and tack welding of a heavy hatch cover is pictured in Fig. 11. Final welding of these covers is accomplished subsequently, outside this jig, utilizing a welding positioner to permit welding in the flat position. Observe that the top is constructed of I-beams welded into checkerboard arrangement for maximum stiffness. The design of the clamps, while not of the quick acting variety, is doubtless dicated by the great force which must be exerted. Note also the use of separate wedges for minor adjustments.

The heavy and complicated jig illustrated in Fig. 12 is for the assembly of hatch side girders and hatch end beams. The web is held horizontal on the heavy channel base. The various flanges and other details attached to the flange are held in a vertical plane. Note the multiplicity of hinged clamps for element along the left edge of the web.

Jigs for shipbuilding need not be large complicated structures. On the contrary, some of the simplest contrivances may be of great value. For example, the simple vee block, a basic element in many jig designs, is illustrated in "grown-up" form in Fig. 13. This frame is here used for positioning a girder to permit down-hand welding.

Another example of simplicity will be found in the jig in Fig. 14, which is for the purpose of fitting the tie braces and supporting elements of a double mooring bitt. Welding of the subassembly is also accomplished in this jig.

It has been stated that careful machine work and fine finish, while highly desirable, are not essential to success in jig designing. A very good, though somewhat amusing, example was found in a shipyard. Obviously, this "Rube Goldberg" (to borrow a popular expression), shown in Fig. 15, has not had the benefit of any engineering design. Nevertheless it performs exceedingly well and, what is most important, does the job efficiently and economically. It is the brain child of an ingenious welding operator. The job pictured is that of welding a reinforcing flange around a pipe opening in a girder. It is an ideal job for E6020 electrodes, and to permit their use a device was required to hold the assembly and rotate it. Holding is accomplished by a four-piece spider made of two flat strips welded at the center, at right angles to each other. Stops are welded at the extremities to retain the work piece. This spider is mounted on the shaft inclined at 45°, to provide the necessary rotation.

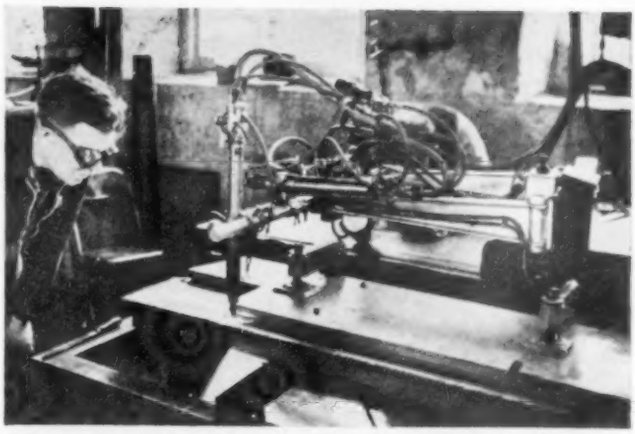

Fig. 19—The Pneumatic Clamping Device Is Here Shown in Use for Cutting a Stack of 50 Thin Sheets

The seat does not indicate that the operator is lazy—rather that he is smart. It provides him with a comfortable position in which to work and this is reflected in higher production and better quality, to say nothing of increased safety.

Discussions of jigs and fixtures are usually confined to those devised for welding, and rarely give consideration to similar devices used to facilitate oxyacetylene cutting. However, the methods employed in jigging may also be adapted to cutting. Some of the ingenious methods that have proved successful in oxyacetylene cutting are included here to assist those who may be confronted with similar problems.

The tremendous requirements of the tank program are doubtless familiar to all. However, the means for meeting these requirements may be new to some. The use of machine gas cutting for the preparation of tank sprockets in large quantities is illustrated in Fig. 16. Here a Travograph equipped with eight torches, four on a side, moves on rails between the setups of plates to be cut. Means are provided for indexing this traveling carriage in terms of the work pieces, which are accurately located on the six cutting tables. At the first and third work stations two operations are performed, that of making the zigzag cut separating the plate in four pieces and also the making of the internal circular cut. Figure 17 illustrates the cutting of sprocket teeth on the periphery. Observe how each piece is held and located by means of the internal circular cut. Also note how the zigzag cut is used for indexing the pieces with respect to each other. By providing two work positions for separating the plate and making the internal cut, it is possible to keep production flowing without the necessity of intermediate stacking of the parts on the floor. In other words, each of the end positions provides a continuous supply of material to the center position for cutting.

For high-production cutting of thin steel sheets, the use of stack cutting offers very attractive advantages. However, one of the difficulties in stack cutting is the clamping of the stacks of steel so that the edges remain in intimate contact. If this intimate contact is not maintained, and an air gap exists, the cut is lost and valuable material wasted. Under some circumstances, simple C clamps prove adequate. On more complicated shapes, however, it is usually quite difficult to provide adequate clamping over the whole surface. The diaphragm or pressure plate illustrated in the drawing in Fig. 18 represents an ingenious method of clamping these parts. It is in effect a bellows welded from sheet metal. The design

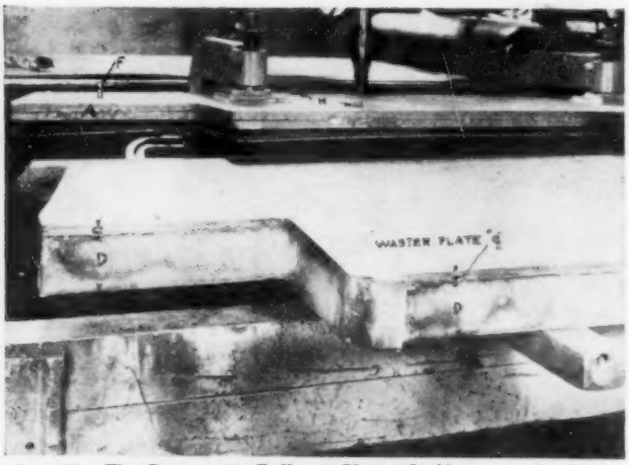

Fig. 20—The Pneumatic Bellows Clamp Is Shown in the Rear, After Removal of the Finished Cut Stack of Plates. Cut Is Exceptionally Smooth

of this bellows merits close study since it is quite novel. Two annular pieces of sheet metal are welded along the inner edges by means of an edge weld. The outer edges of these annular pieces are then welded to the sheet metal top and bottom of the bellows. An air inlet, more or less centrally located in the top sheet, is provided. This bellows is backed up with a top pressure plate. The bellows or diaphragm is made slightly smaller than the actual cut so that it will not interfere with the free movement of the cutting tip. Another pressure plate on the bottom provides the other element of the clamping arrangement. Heavy C clamps provide the tie-in between the two pressure plates. Introduction of 25 psi. air pressure to the bellows effectively applies sufficient force over the stack of sheets to bring them into the desired intimate contact. On top of the stack is the waster plate commonly used in stack cutting.

In Fig. 19 this jig is shown in use holding a stack of fifty 18-gage sheets for cutting by a Planograph. Figure 20 shows the cut completed and the stack removed from under the diaphragm.

In its present application no cutting is performed at the rear of the stack. However, should cutting be necessary, several means could be developed to permit cutting while maintaining the tie-in presently provided by the clamps. This might be accomplished by hydraulic jacks operating fr om an overhead beam or the ceiling. Another method would be to use quick acting clamps. Obviously, any of these devices would have to be moved as the cut progressed so as not to interfere, yet once the cut passed the spot, they must be replaced to restore the clamping effect.

The devices so far considered have been of the type designed for specific application, in contrast to those suitable for general use. The latter type is generally referred to as welding positioners. In this field remarkable strides have been made in both size and design. Where a positioner capacity of 14,000 lb. was large before the war, today the larger editions will accommodate weldments as heavy as 35,000 lb. and even more. Another interesting extension of these devices has been the development of what might be termed the "lathe type" positioner, for handling more or less cylindrical weldments. They consist simply of a power-driven headstock at one end with an idling tailstock. All of these positioners have played important roles in enabling welding to meet mass production requirements. Rows of them are common sights in many plants.

The jigs and fixtures covered by this brief discussion are by no means a complete review of those used in war production. Many of the finest are still obscured from general view and study by the cloak of censorship. When this is lifted we shall have available a vast source of information on this very important subject, which may well change our perspective of the problem. It is to be hoped that those who have contributed so effectively to war production will later reveal to industry the equipment they have developed, including the jigs and fixtures for welding.

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(*Continued on page 23*)

Design of Welded Machinery*

By John Mikulak†

Introduction

WELDING as a production tool is perhaps the most vital factor in the success of our present war production effort. Whether it will continue to enjoy its present position in the postwar era will depend upon the ingenuity of our engineers, designers and operators.

The phenomenal contribution of welding to the war effort has been made in spite of rather than because of adequate planning and study of the best and most economical and efficient procedures and design. And, if the enviable record of welding is to be maintained in the postwar era considerable research and effort must be devoted toward its application to peacetime pursuits on a wider basis and with assurance of satisfactory and efficient performance.

In general, the engineer and designer have not used welding to its fullest advantage. This in many instances is no doubt due to the pressure of emergency requirements and as a consequence little or no time is allowed for either proper design or procedure. However, there are many instances where examination will disclose that improper design has been due to a limited knowledge of the welding process. It is not enough merely to substitute welding in a cast or riveted design. Many of our difficulties with welded structures are caused by such a practice. Welding as a production tool is versatile and is easy to apply. However, there are many inherent characteristics of the welding art which require special consideration and sets it apart from other forms of fabrication. The purpose of this paper is to re-emphasize some of these characteristics.

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944.

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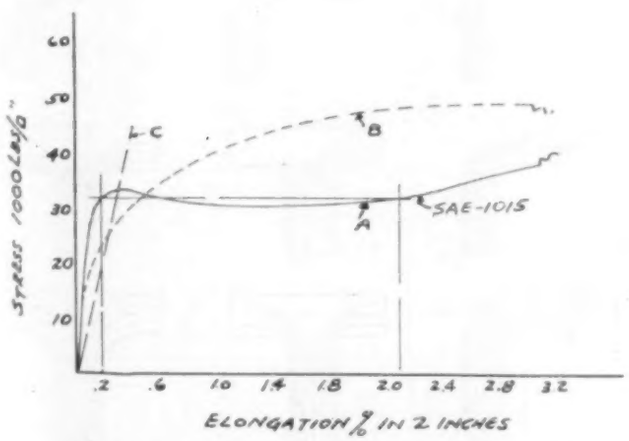


Fig. 1—Elasticity Curves Showing Affinity for Slip and Rates of Slip at Various Stresses

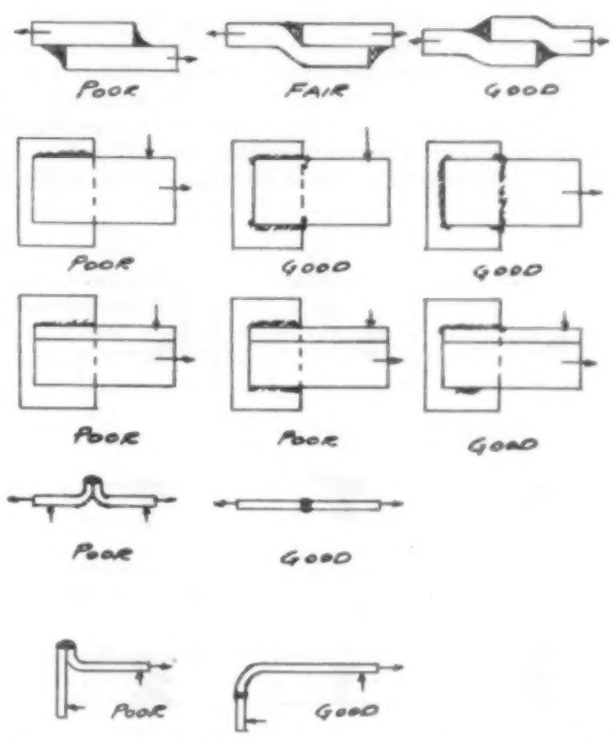


Fig. 2—Unbalanced Joints and Illustration of Obtaining Better Balance

Selection of Materials

All steels and most of the other ferrous and nonferrous metals are weldable under proper conditions. However, many of these metals require elaborate, time-consuming preparations to obtain the proper welding conditions. Therefore, whenever possible, the metals chosen should possess good welding characteristics or weldability, i.e., the common low-carbon steels. These steels have in addition to desirable mechanical properties the additional advantage in that generally higher welding speeds may be used than on the complex alloys. There is, however, a trend to make use of high-strength alloys primarily to reduce the weights of weldments. Use of these high-strength steels and nonferrous alloys in the postwar era will require special adaptation of the welding processes to produce more satisfactory cost results. There are many other factors in addition to weight reduction that require special steels and nonferrous alloys, such as abrasion, friction, conductivity, corrosion resistance to various fluids and gases, etc. In many instances use of special materials can be avoided by making use of surface deposits which can be applied by welding, spraying, plating or painting. Flame strengthening or hardening can also be used to obtain proper physical requirements in the critical areas.

The success of weldments as well as other forms of fabrication is generally weighed first, on the basis of cost and second, on performance. While this may not be a fair standard, nevertheless, it is a challenge and the designer must be prepared to meet it. The use of low-alloy steel enhances the possibilities of obtaining low-cost weldments by utilizing this low-cost material which combines excellent workability and weldability.

One of the principal properties of metals selected for low-cost weldments is ductility. This phenomenon is actually molecular slip in the grain structure of the material. Figure 1 illustrates three curves which are characteristic of the manner in which this slip occurs. Curves A and B are characteristic of ductile metals while Curve C is characteristic of brittle metals.

A material without affinity for slip as shown in Curve C requires considerably more care and setup for application to welding than materials with affinity for slip as shown in Curves A and B. Curve A is characteristic of the low-alloy steels and from this curve it can be seen that 2.1% deformation can be obtained in the structure

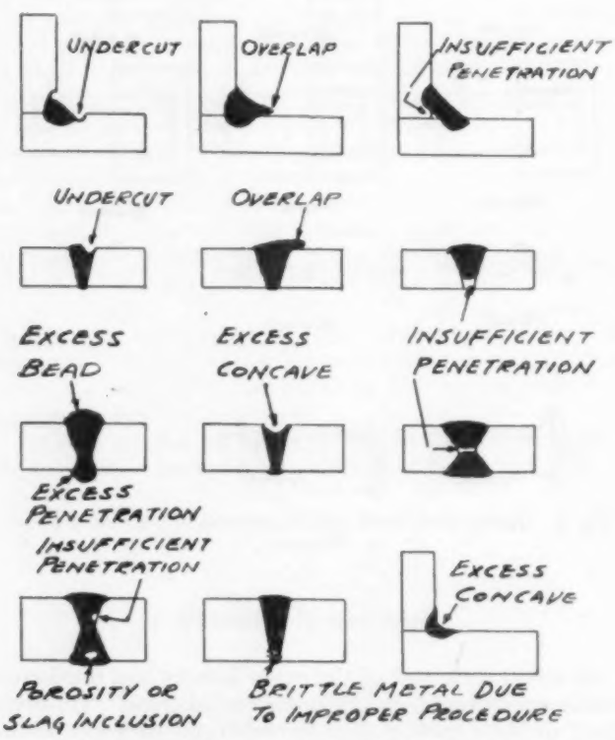


Fig. 3—Discontinuities in Welded Joints

without exceeding the yield point of the material. On the other hand, curve C which is characteristic of a cast iron will produce fracture at only one-sixth of the deformation of low-alloy carbon steel shown in Curve A. Because of this fact, it can be concluded that ductile metals can be welded successfully with considerably less difficulty than brittle metals as concentrated stresses caused by localized thermal forces can be relieved without fear of fracture. It, therefore, is seen that the weldability of a metal must be considered from the metallurgical aspect before the final decision is made.

Joint Design

Stresses are set up by thermal forces, externally applied forces or gravitational forces. These forces set up

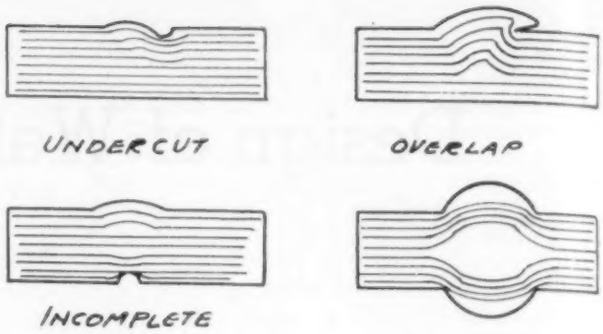


Fig. 4—Stress Flow in Weld Discontinuities

shear, tension or compression stresses. The magnitude of the stress depends upon force and section as well as the manner in which the force is applied. It is worthy to note that the efficiency of a section to carry load is minimum when produced by a bending or a twisting moment. Therefore, in designing whenever possible, bending or torsional moments should be avoided.

Stresses flow through a section or a joint similar to liquid in a hydraulic system. A discontinuity interrupting the flow will cause concentration of stresses similar to the eddy currents in a hydraulic system. Further, the resisting force of the section under stress attempts to align itself with the externally applied load. Since this phenomenon causes severe stress concentration especially if the latter creates a bending moment such practice should be eliminated whenever possible. Figure 2 illustrates some of the more common causes of unbalanced joint design and how they can be corrected.

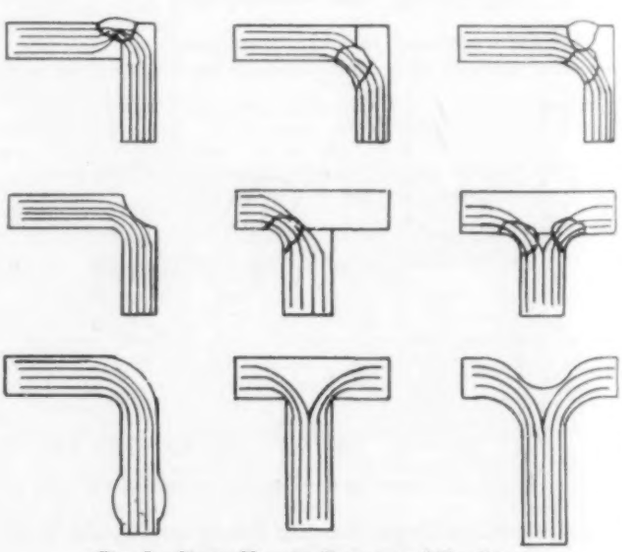


Fig. 5—Stress Flow in Corner and Tee Joints

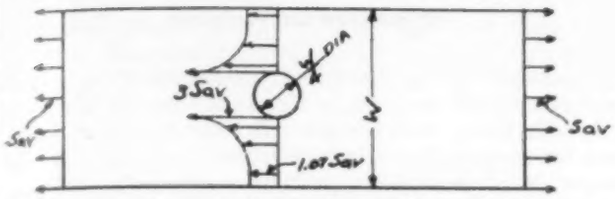


Fig. 6—Stress Concentration in Tension Bar with Hole Constituting Discontinuity

It can be seen that in some cases unbalanced joints are made because of the convenience the particular joint affords in setup and fit-up. This type of joint may be permissible and be perfectly safe, provided the stress conditions permit its use.

Elimination of undesirable conditions in stress flow must also involve consideration of the discontinuities caused both by the welding process and the joint design. Figure 3 illustrates the common forms of discontinuities in a welded joint. Each of these discontinuities causes stress concentration and care should be taken to eliminate them by a proper welding procedure and technique. Figure 4 and polaroscope models show the effect of stress flow, caused by various discontinuities. Most of these are inexcusable as they are the result of improper workmanship or design and the cost of eliminating them is small and generally consists merely of requiring sufficient training of the operators and designers. The design should be such as to make possible sufficient fredom for the operator to manipulate the arc properly and thereby produce a good joint.

Undesirable stress flow can also be caused by improper joint design. Figure 5 illustrates examples of this effect on tee and corner joints. Polaroscope models of the conditions in Fig. 5 illustrate very vividly the effect of the stress distribution and flow in these joints. The effect of stress concentration, however, is not as serious in ductile metals as it is in the brittle metals, because the affinity for slip in the ductile metals will allow the concentrated stresses to be relieved by local plastic flow of the material at the stress areas and thereby enable their distribution into the section.

The importance of stress concentration is sometimes overlooked because generally only average stresses are calculated. Figure 6 illustrates a simple tension specimen with a hole in the center simulating a defect from which it can be observed that the stress at the hole is 300% greater than the average stress. If this member is of a brittle material the average stress must be reduced by increasing the section to obtain a safe maximum stress. However, in a ductile metal this stress will be relieved by plastic flow provided the joint is such that this flow can be dissipated uniformly so that the maximum unit strain will not exceed the ultimate strength of the material. An incompletely welded joint or a notch at the surface of the hole would produce a condition in which this stress could not be dissipated uniformly, as a result a failure would result.

Before passing the subject of joint design, a misguided interpretation should be brought out in that there is a growing tendency to make the user of welded fabrication feel that each joint must have a continuously perfect weld, with excellent deposit, complete penetration, smooth contour, etc. While this, in general, is true, however, actually each joint should be engineered to take care of only the actual loads imposed on it. In many instances where members of a weldment are designed from a standpoint of stiffness, the plate thickness may become large and therefore, the unit stresses will be low. In such cases it would be unwise to make the joint strength equal to the plate strength as it would prove uneconomical especially if the load is essentially of a static nature. Generally the amount of weld should be determined so that the stresses in the welded joints will be approximately equal to that allowed by the particular code or specifications. It should be pointed out that undesirable stress flow is such only when its presence produces unsafe stresses. However, the designer should be familiar with this phenomenon and specify the correct joint and weld procedure.

There are special cases, however, where the joint must be of equal stiffness to the plate, even though the stress is low in order to obtain desired effects. Figure 18 illustrating such a case, is a cross section of the frame shown in Fig. 14, in which the frame stiffness must be

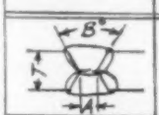
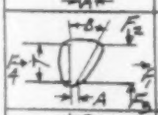
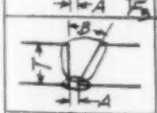
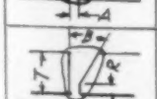
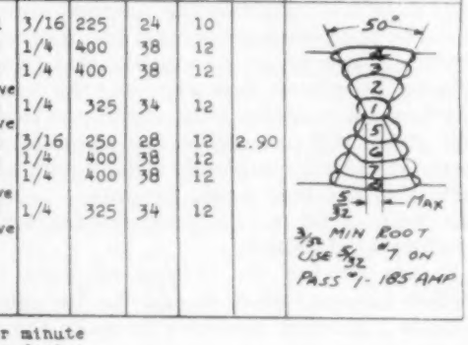
Section	Welding Symbol	Thickness T"	Root Opening "A"	Bevel Angle B°	Reinforcing 2"	Max. Eff. %	
	8 T	1 3/4	3/16	80	1/4	100	Use for all loads.
		3/4	1/8	60	1/8		
	5 T	3/4	5/32	60		70	F_1, F_2, F_4 may be static or moderate dynamic loads. F_3 moderate static loads only.
		1/4	1 1/16	40			
	5A T	3/4	5/32	60		80	Use for all moderate static and dynamic loads.
		1/4	1/16	40			
	5 T-R	3/4	5/32	60	5/32	80	Use for moderate static and dynamic loads except F_3 use only static and light dynamic.
		1/4	1/16	40	3/32		
	5A T-R	3/4	5/32	60	5/32	90	Use for all loads
		1/4	1/16	40	3/32		
	7 T	1 1/2	5/32	60		60	Use for all moderate static and dynamic loads.
		1/2	1/16	40			

Fig. 7—Joint Procedure Showing Necessary Dimensions and Engineering Data

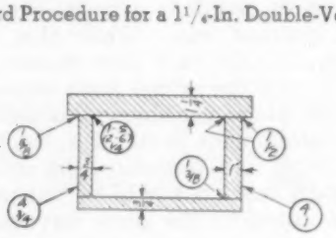
Flat Position
Joint 8
400-Amp. Maximum Size Welder

Plate Thickness	Type Rod	Pass No.	Rod Dia.	Amps	Volts	*Arc Speed	**Lbs Rod	Bead Procedure
1¼	7	1	3/16	225	24	10		
	9	2	1/4	400	38	12		
	9	3	1/4	400	38	12		
		Weave						
	9	4	1/4	325	34	12		
		Weave						
	9	5	3/16	250	28	12	2.90	
	9	6	1/4	400	38	12		
	9	7	1/4	400	38	12		
		Weave						
	9	8	1/4	325	34	12		
		Weave						



* inches per minute
** pounds per foot

Fig. 8—Standard Procedure for a 1¼-In. Double-Vee Butt Weld



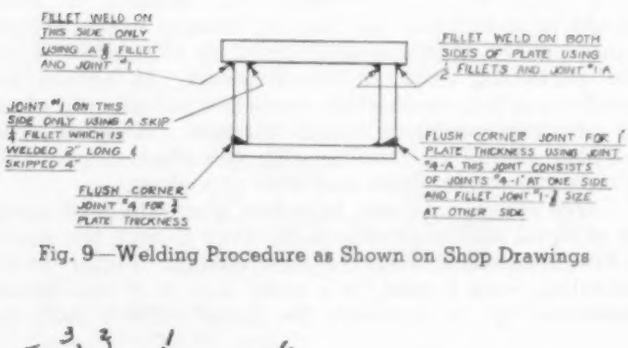
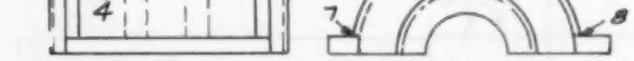

FILLET WELD ON THIS SIDE ONLY USING A ⅜ FILLET AND JOINT #1
JOINT #1 ON THIS SIDE ONLY USING A SKIP ¼ FILLET WHICH IS WELDED 2" LONG & SKIPPED 4"
FLUSH CORNER JOINT #4 FOR ½ PLATE THICKNESS
FILLET WELD ON BOTH SIDES OF PLATE USING ½ FILLETS AND JOINT #1A
FLUSH CORNER JOINT FOR 1" PLATE THICKNESS USING JOINT #9-A THIS JOINT CONSISTS OF JOINTS #9-1 AT ONE SIDE AND FILLET JOINT #1-½ SIZE AT OTHER SIDE

Fig. 9—Welding Procedure as Shown on Shop Drawings



Welding Sequence: Joints 1, 2, 3, 4 and 5 in positioner 45° from vertical. After welding joint 3 hammer down block and weld joint 4 in vertical down position. Swing cap in jig and make joint 6 in 45° from vertical. Turn cap in horizontal position, rotate 45° and weld joint 7, then turn 135° and weld joint 8. Fit cap to base and weld on seals at joints 9 and 10.

Fig. 10—Welding Sequence for Pedestal Cap

calculated to determine the frame frequency. For this reason the welded joint must be of sufficient stiffness to make all members of the frame act as a unit energy mass so that calculations will correspond to actual conditions. In this application the welds are necessarily large, therefore, the stresses usually are low or between 900 and 2500 psi.

There are many factors to consider in the selection of the joint which may appear contradictory. However, these factors consider the practical aspects of welding and have been found to be perfectly safe. It is the welding engineer's duty to see that these factors are both analyzed and applied correctly to the weldments to obtain the most workable and economical design.

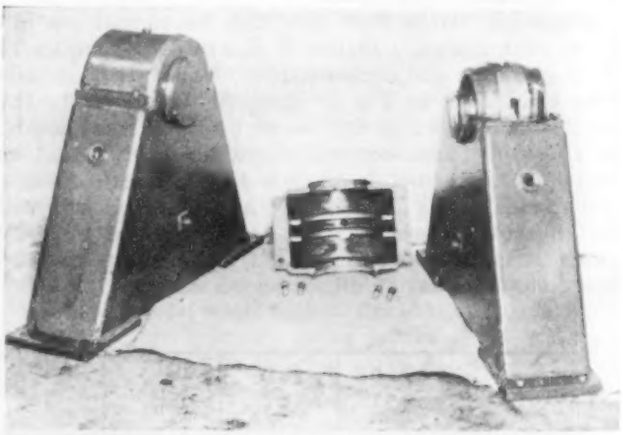
Procedure for Welding

In designing, the foregoing fundamentals should be kept constantly in mind as the design and welding procedure is being worked out. It may be worth noting that far more failures in weldments are caused by improper design or welding procedure rather than by poor welding technique by careless or inexperienced operators. Welding procedure and welding technique are not to be confused and should be thought of as two branches of welding.

Welding procedure is a factor in design and is in a good many instances more important than the actual design itself. The engineer and designers must be familiar with this branch of the welding and specify the welding procedure on the drawings being sent to the shop. Welding procedure should specify the correct type of electrode, electrode size, welding amperage, voltage, arc speed, type of joint, size of weld, bead procedure, fabrication sequence, welding position and heat treatment if required.

Welding technique is the branch of welding in which the primary interest is fabrication of the weldment as directed by the procedure. Proper arc manipulation, bead contour, bead size, penetration and skilled operation of the welding equipment being used are the important factors to be considered. I believe, and it is gratifying to know, that in general, welding technique is

Fig. 11—Welded Bearing Pedestal with Pedestal Cap Removed



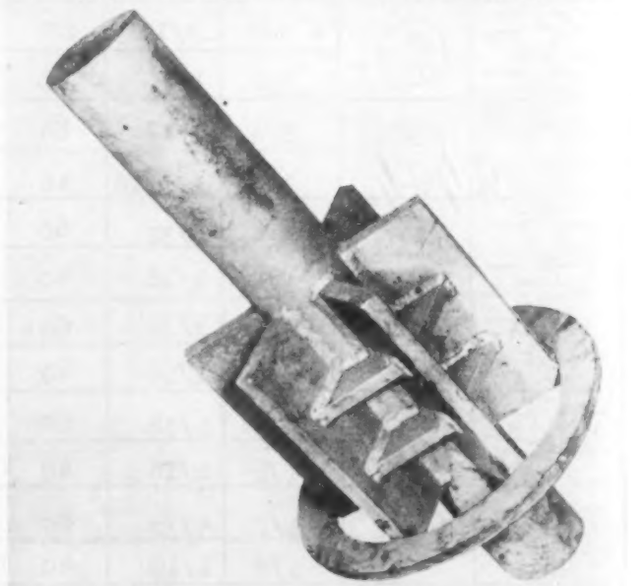


Fig. 12—Spider for a Motor Welded Integral with the Shaft

understood more thoroughly by the operator than welding procedure is understood by the engineer or designer. This fact should instill confidence in the latter group toward the operators.

All manufacturers using welding as a production tool should set up standards to obtain uniform quality, of materials, production and manufacturing cost. Each joint being used should be standardized for proper fit-up so that the type and size of electrodes specified can be used effectively. Variations in joint fit-up should be provided for by proper and uniform processing of the joint. Figure 7 illustrates a joint procedure that is being used by the organization I am associated with. The welding procedure for a weld in one of the joints shown in Fig. 7 is shown in Fig. 8. Figure 9 illustrates how the information in Figs. 7 and 8 is shown on the drawing being sent to the shop. The fundamental theory behind this standard is that only welds on the near side can be shown and it is necessary to choose the correct view on the drawing to illustrate the correct location of the weld. It should be pointed out, however, that it is not necessary to set up a complete set of new standards as the AMERICAN WELDING SOCIETY has set up many of these standards and they are available to the industry. However, I feel that our procedure is somewhat more easily read and understood by the men in our organization.

The standard procedures should cover every joint for every position in which each may be welded as well as for the various types of equipment each joint will be produced with. This may appear as a tremendous task but it is not difficult if done in a steady sequence as progress is made in the application to actual weldments. It is to be expected that various operators will not strictly follow this procedure but, certainly, a criterion is established for the organization to work with and the final results will be found very gratifying.

Another very important phase of standardization is the welding fabrication sequence. The welding sequence should describe in detail how the various elements of the weldment should be set up, tack welded, clamped and sequence of welding the various joints. A standard welding sequence with a standard welding procedure will make it possible to produce weldments with uniform quality and cost with minimum residual stress and distortion on large production line jobs. Figure 10 illustrates a welding sequence for the bearing pedestal cap design shown in Fig. 11 and is typical of the required outline. Welding sequence is of great value when weldments are being set up on an incentive program.

Illustrations of Typical Welding Procedures

Importance of welding procedure can be illustrated by bringing to attention examples from actual experience.

Figure 12 illustrates a spider for an electric motor. The spider consists of several ribs welded to the shaft. These ribs are not shaped to fit the curvature of the shaft. This results in a narrow deep root opening between the rib and shaft. There are at least two suitable procedures for welding this joint and the method depends on the strength of the joint required and the type of load the joint will be subjected to. If full penetration is not required, the joint can be made by two single-pass fillet welds—using sufficient heat to obtain the required penetration. The remaining procedure consists of making the joint with two fillet welds, each fillet made with two beads—using an electrode which builds up on the first pass (A.W.S. 6011 or 6012) to bridge the poor fit and the second pass made with a high-speed rod (A.W.S. 6030).

Using 520 amp. with a $^3/_8$-in. electrode (A.W.S. 6030) in the flat position, single pass, will not produce a suitable joint as difficulty is encountered in obtaining proper penetration because the long root opening constitutes the equivalent of a bad fit-up. This makes it necessary to use slow arc speed in order to fill up the crater. The hot arc pool dissipates the heat energy from the arc and prevents proper penetration and as a result a shallow concave bead is deposited. Further, the increased puddling time washes carbon from the steel shafting (S.A.E 1025) into the weld pool and decreases the ductility of the deposit. The joint upon cooling contracts and causes the rib to pull up against the shaft which results in a

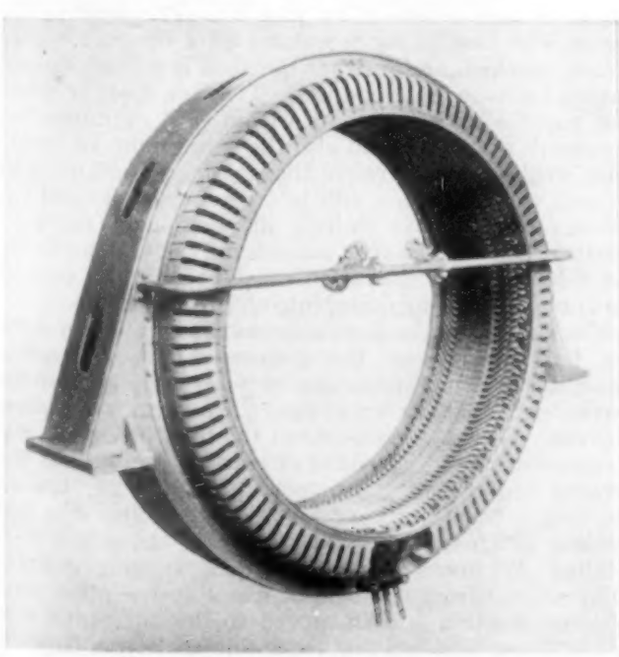


Fig. 13—Stator for a Motor Showing the Shell Which Is Welded After Stator Core Is Stacked

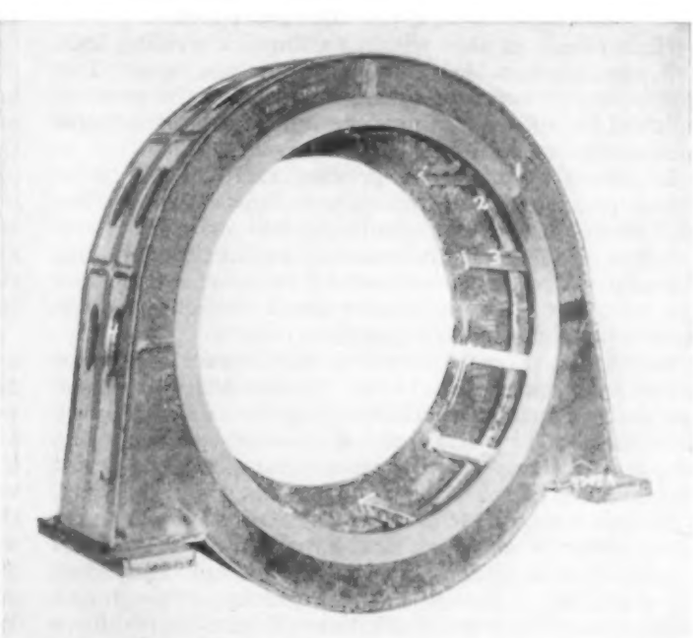


Fig. 14—Stator Frame for a Large Motor Showing Construction Details

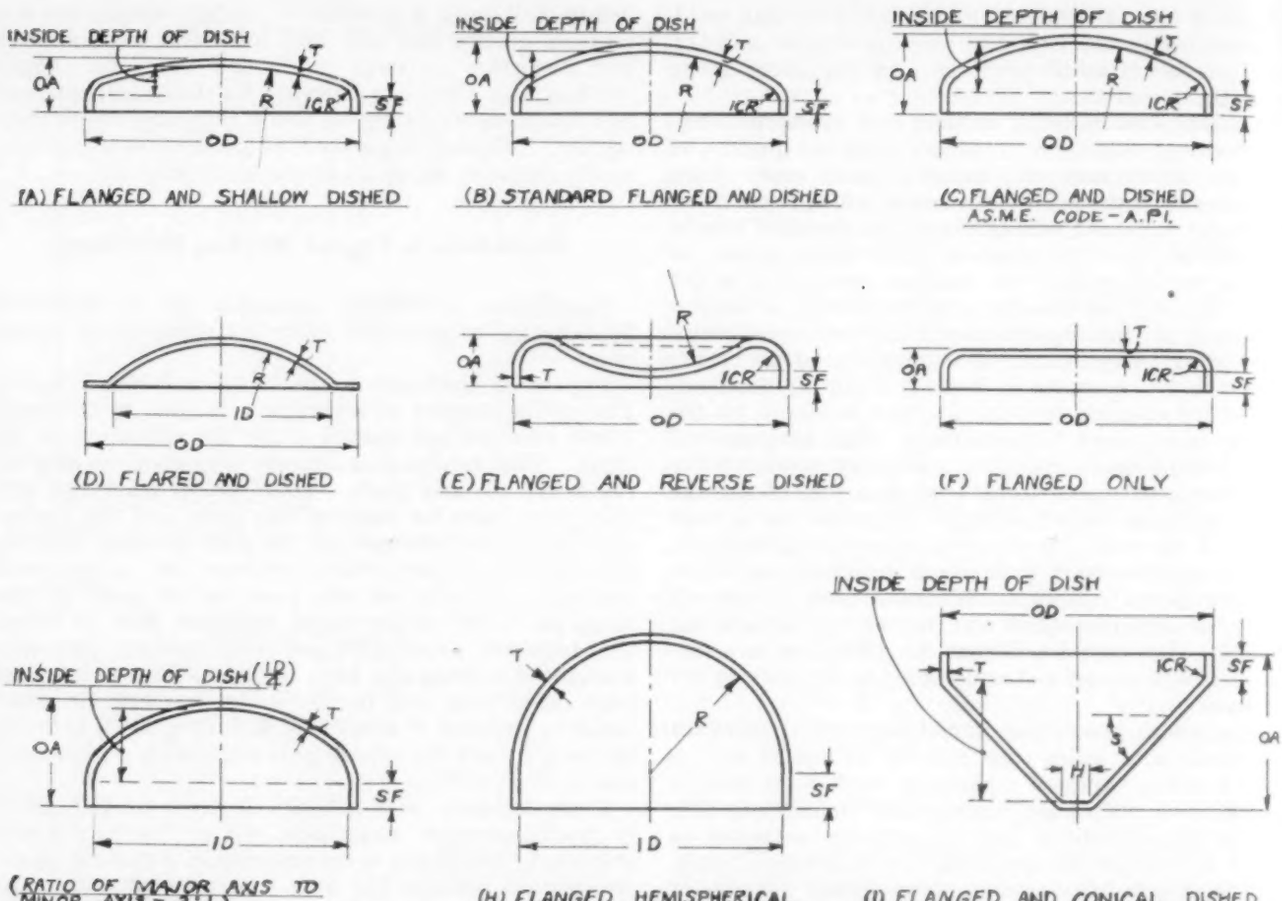


Fig. 15—Shells That Are Available for Machine Designs and Which Can Be Incorporated in Weldments to Reduce Welding

joint with greater stiffness than the strength of the deposited bead which as a result produces a cracked weld. Spacing the rib away from the shaft increases the root opening and causes greater difficulty with this procedure. Preheating the shaft and ribs produces better results with the two single-pass fillet procedure.

Higher heat as used with an automatic welding head will produce suitable results with a single bead. Due to the tremendous amount of energy used the penetration will be sufficient to produce sufficient bead strength to resist forces set up in the cooling cycle.

In using two passes to produce each fillet as mentioned previously the first pass is deposited with less heat and consequently results in less maximum temperature, produces less contraction, and at the same time the relative cross-sectional area of the bead is somewhat greater. The greater relative bead section and less contraction force produces excellent results.

Another point of interest is the reinforcing brace placed between the axial ribs. It was desired to place and weld these braces before welding the axial ribs to the shaft and thereby serve as an accurate spacer for the set-up operation. This required welding from each end of the axial rib to the center bracing rib. However, when this was done, the weld deposited on the first end of the spider would crack as the weld on the second end was being completed. The difficulty is apparent when the condition is studied. The expanding cycle during welding on the latter end created sufficient thermal force on the weld at the first end to cause failure. The fact that the joint is made by partial penetration, causes a stress concentration on the root of the weld which contributes to the failure. Difficulty was overcome by supporting the axial bars in a jig and making all welds continuous across the full length of the axial rib and later adding the reinforcing braces.

Another instance illustrating the importance of welding procedure is shown by Fig. 13. The shell of this motor is welded to the sideplates after the core is completely stacked, and, further the shell is welded without having the core on a mandrel. The core must be round and parallel with the shaft within plus or minus five thousands of an inch and also the core cannot be turned after welding and therefore the welding procedure must be such that the frame will be free of excessive residual stresses to eliminate shifting in position of the core. Further, because the shell extends only over a portion of the sideplates, consideration must be given to prevent the frame from being pulled into an eliptical shape.

The latter consideration requires distribution of welding heat. However, the former condition requires minimum residual stress and requires welding from the vertical center at the top toward the feet in a continuous manner. As may be suspected the final procedure was a compromise and consisted of starting the weld at the vertical center line of frame and welding 25° toward the feet. Then shifting to horizontal center line and welding 25° from it toward the top of frame and then welding 25° toward each foot—the welding position being shifted from one side of frame to the other side. Welding position is then moved to the 45° center line of the frame and welding from this centerline toward the top of unit and then toward the feet. Finally, the weld is complete at the foot of the frame. This pro-

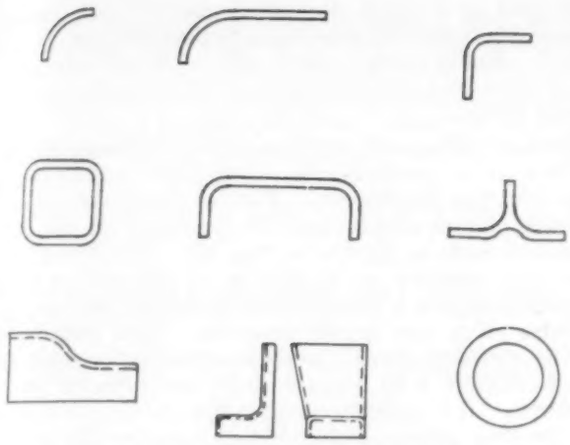


Fig. 16—Suggested Shapes Required to Produce Low-Cost Weldments

cedure allows the finished structure to remain round within specified limits and also evidently reduces locked-up stresses to a point where no perceptible change in dimensions is noticed as the structure strain ages.

Welding the same frame by starting at one foot and welding continuous to the other foot will cause out-of-round condition of the core to as much as one tenth of an inch.

The influence of aging of welded structures appears to be affected considerably by various welding procedures. Figure 14 illustrates a frame for the large motor and generator ratings. Frames of this type are bored after welding. However, if these frames are bored immediately after welding, they will go out of round approximately 0.093 in. on the diameter. If these units are welded by beginning at the vertical center line and welding in areas of 20° from each of these positions, working simultaneously from both top and bottom of the frame, and welding toward the feet, the units will age sufficiently in 15 days to reduce this out-of-round condition to as low as 0.006 in. However, if on the other hand the welding is done by welding from one foot to the other foot this out-of-round condition will still be approximately 0.015 in. after an aging period of 22 days.

Returning to Fig. 14 the fabrication sequence for welding all the joints, must be such that all circumferential joints are made first and then finished by welding in the corner braces and ribs. A reverse fabrication procedure where welding is started by welding the ribs first will produce cracked welds at the ribs. The first procedure allows the ring parts to shrink and rotate freely as the circumferential welds are being made and has proved to be highly successful.

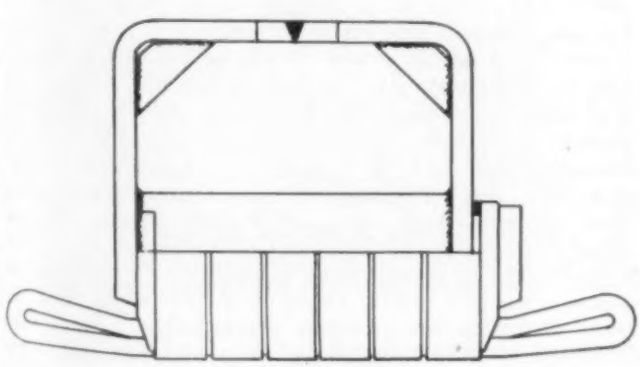


Fig. 17—Cross Section of Design for Large Frame Using Shells with Centers Removed

Uniform welding procedure is very important on precision-welded assemblies made with the use of jigs. The bearing pedestal cap shown in Fig. 11 can only be removed from the jig with considerable difficulty if it is not welded in accordance to the procedure shown in Fig. 10. In designing jig assemblies, the welding procedure should be decided upon before the design of the jig is completed as the latter is influenced by the conduct outlined in the procedure.

The bearing pedestal in Fig. 11 can be used to show the importance of proper jigs with a suitable welding procedure. A pedestal requiring 6.5 hr. for the welding time without a jig can be reduced to 1.8 hr. with a proper jig. However, the latter time can be increased up to 3 hr. on the same jig if the procedure issued is not followed.

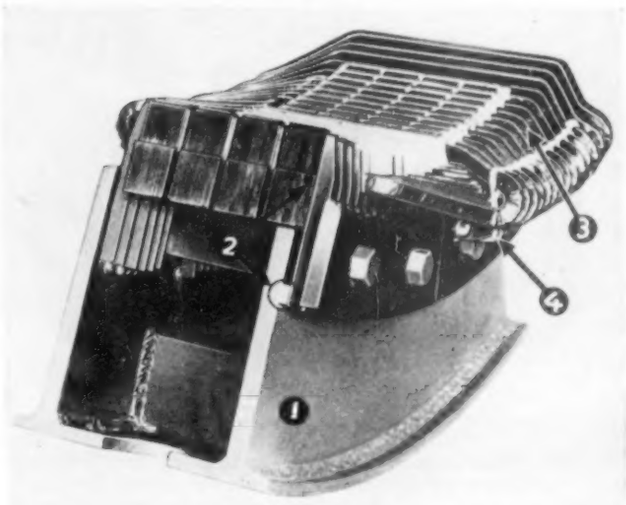


Fig. 18—Cross Section Through a Present Welded Stator Frame

Residual Stresses, Distortion and Stress Relieving

The latter examples indicate that proper procedure with an aging period would make stress relieving by heating unnecessary. I believe this is true as the above examples give postdimension stability performance which is approximately 80 to 90% of properly annealed structures. Many mild steel structures are stress relieved unnecessarily; thereby increasing manufacturing cost. Figure 11 is also an example where it was found unnecessary to stress relieve, as satisfactory results have been obtained in the past 3 yr. by dispensing with it and substituting a 12-day aging period. However, in cases where high stresses are involved and where absolute maximum postdimension stability is required, stress relieving by heating is a good solution.

It should be pointed out, that welding sequences in which minimum locked-up stresses are produced during welding will materially assist in producing desirable postdimension stability. Welding to open joints reduces residual stresses to a minimum. However, this practice produces large initial distortion and therefore, it is important that elements of a weldment which must be machined or must fit adjacent weldments, are welded after the substructures are completely welded and thereby eliminate a major portion of the distortion due to welding operation.

The stress-relieving equipment and the stress-relieving operation place an appreciable expense item on the small fabricator. In many cases correct application of welding will not require stress relieving and can be dispensed

Fig. 19—High-Speed Motor Design Using Formed Shells

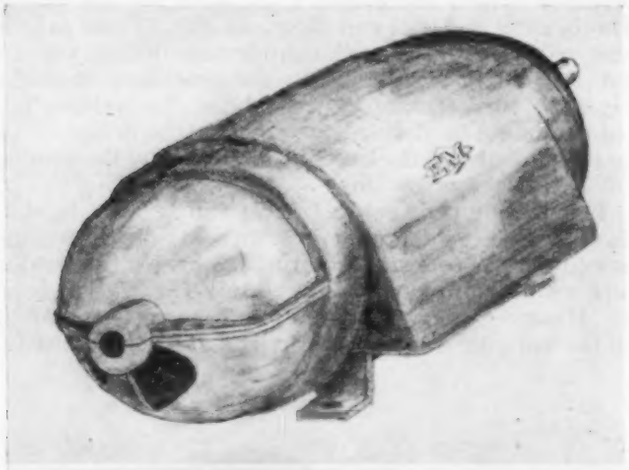


Fig. 20—Small High-Speed Motor Using Shells and Baffles to Improve Appearance and Direct Ventilating Air

with. Further study will produce more useful data on this subject.

Design Trends

In the latter years before the present war era, the industrial product designer, made considerable progress in making the buyer and user of industrial products conscious of appearance. This trend has been somewhat curtailed by the war effort. However, the display of postwar models makes it apparent this trend has been constantly in the background of postwar plans. As a result attention must be focused on this element in design. Naturally, it is difficult to forecast in detail what our philosophy of appearance will be 5 or 10 yr. hence. From present indications, however, it appears rectangular figures with gracefully curved corners will be predominant. Fortunately, as previously discussed, this type of figure is ideal for stress distribution in weldments and therefore will not hamper performance of such weldments.

The future design tendency will without question demand more from our rolling, forming and stamping industries. At this very hour, there is a grave need for proper shapes and forms which could be incorporated into designs to produce more economical and pleasing appearing weldments. My close contact with the electrical motor and generator industry makes me feel confident that the design and appearance of this product will be influenced by shapes and forms—assuming they can be purchased at proper price and with proper deliveries. At present, due to an apparent lack of rolling and forming equipment, deliveries as well as cost run high and as a result discourage use of such elements. Figure 15 illustrates several shells that are now available and no doubt many others will be made available as these elements are introduced into various machine design fields.

Present rolling mill practices do not produce the most desired cross sections for application to weldments. This fact was illustrated in Fig. 5. There are many additional shapes which could be produced by the rolling industry such as shown in Fig. 16. The forming and stamping industry could also be of material assistance in producing such elements as standard machine feet, annular rings and corner brackets. New welding and rolling methods should produce rolled and welded rings at prices from 2 to 4 cents above the price of the raw material. It is entirely possible that in the postwar era, the greatest strides in the welding industry will be made in producing these elementary shapes rather than in developing new welding machines and welding electrodes.

A proposed cross-section assembly through a large electric motor frame shown in Fig. 17 demonstrates the influence shells could produce on this product. Here, two flanged shells are used, with the centers removed, to form the frame. Figure 18 illustrates the present design of the same frame. The amount of welding is decreased 70% in the proposed design and in addition, due to simplified set-up procedure required, the set-up time would be decreased an additional 65%.

Figure 19 is an artist's conception of a large high-speed motor made from pressed shells and stampings. This unit is actually going through production as an experimental model. This design, from cost estimates, should reduce manufacturing cost of the structural elements approximately 42% over the present conventional welded design. In many cases, to obtain economy and low weight, it is possible to make a substructure of very simple open construction and by use of shells drawn from sheet steel, cover the structure to obtain pleasing appearance. The covers or shields, in addition, can also provide additional necessary functional operations such as shown in Fig. 20. The covers in the latter provide protection from moisture and foreign matter, and also direct ventilation.

Simplicity of design cannot be overemphasized as a positive means to accomplish low cost, good appearance and functional design. In this present period of restricted availability of materials, it is patriotic to use all the scrap material possible. However, this may, and in many cases does, increase the manufacturing cost by requiring extra labor in cutting, welding and setting up operations to make it possible to use the scrap available. The final outcome is a higher man-power demand which in many cases is more critical than the material shortage involved. Cutting scrap by use of the gas torch, for corner braces in Fig. 15 requires approximately 300% more labor than shearing them from bar stock, and, in addition, the cutting operation requires critical material. Therefore, care should be taken when planning to incorporate scrap as parts material.

Precaution should also be taken when designs for welded construction are made to fit available jigs and fixtures built for other forms of fabrication. Care should be exercised that such a procedure will not in any way hamper sound functional welded design. For instance, it is unwise to make the welded design a few inches larger in diameter, or a foot plate thicker, or add a few extra ribs merely to fit an available jig that has been designed for cast-iron construction. Steel construction is stiffer and stronger than cast iron and therefore full advantage should be taken of this fact to obtain maximum economy.

The suggestions and examples brought out in this paper indicate that there is a considerable amount of pioneering to be done in establishing the welding industry as a universal means of fabrication. Welding and the welding industry is by no means in its infant stage. However, the welding industry cannot consider itself fixed until the art is made so familiar that the word "welding" impresses the layman with a definite and exact conception of the process involved.

In closing I wish to express my appreciation to Prof. T. P. Hughes of the University of Minnesota for his assistance and suggestions in producing this paper.

Quartermaster Blacksmith and Welding School*

SOME of the most modern up-to-date equipment known to the welding industry is now in use at the Quatermaster Blacksmith and Welding School of Camp Lee's Army Service Forces Training Center—aiding in the training of skilled QM welders to take their place in the Army's vast network of service and supply throughout the world.

For example, two 500-lb. acetylene generators have been installed at the school for the generation of its own acetylene gas. This is the largest size known to be used in the industry and there are not too many of them in existence.

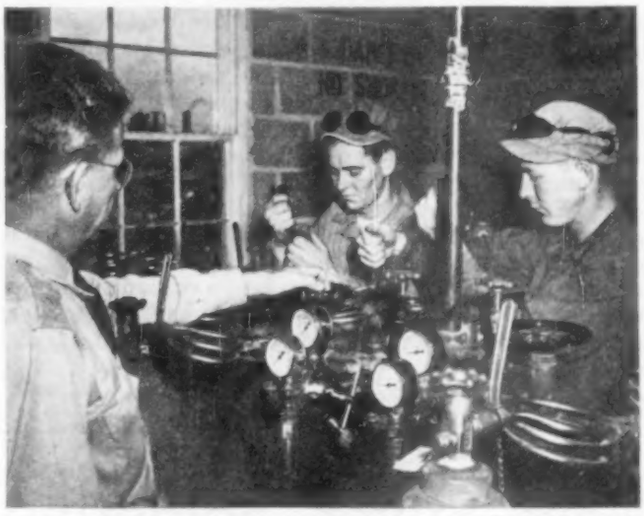
The construction of the generator system was accomplished entirely by soldier labor, and the amount of money spent in its construction was saved during the first eight months of operation, since carbide was bought in larger quantities at a saving. Also, following installation of the system, gas leakage and that wasted in hooking up the tanks was eliminated.

The gas, generated by combining calcium carbide and water, is piped underground into the welding shop from across the street. In the generator building is also located a 22-bank manifold system for tanks of oxygen, which likewise is piped to the shop underground. The acetylene and oxygen are used in the 48 stations of the shop, where complete equipment—minus the tanks—are set up. By combining acetylation gas and oxygen in the welding school, a heat of as high as 6600° F. can be produced.

The idea for the generator system was that of Thomas H. Shinault, head civilian instructor at the shop. He is planning to secure an oxygen generator to go with the acetylene one. A native of Richmond, Va., Mr. Shinault has been welding for 30 years.

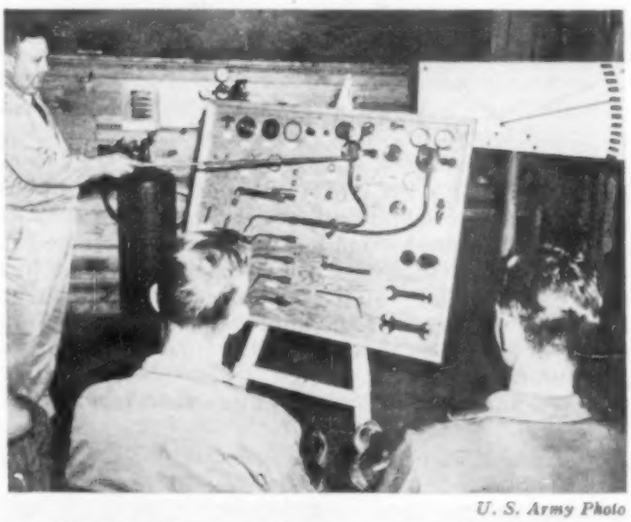
Also a veteran welder is Lieutenant Charles Unger, officer in charge of the shop. He worked with a large electrical manufacturing company in Pittsburgh prior

* Public Relations Office, ASFTC, Camp Lee, Va.



U. S. Army Photo

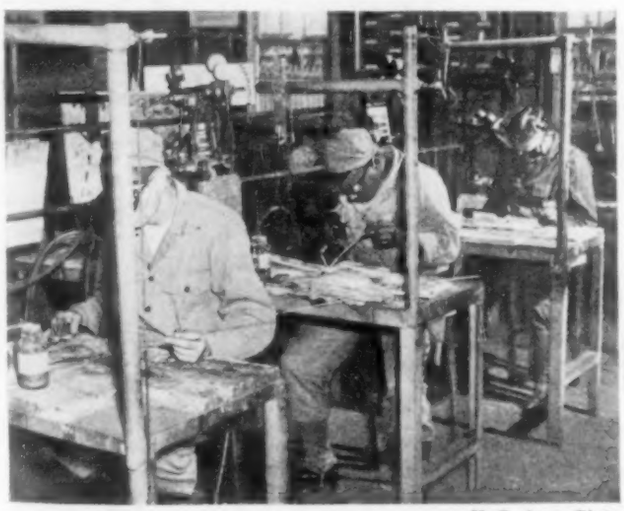
Charging a Bank of Oxygen Cylinders on the Manifold Line



U. S. Army Photo

A Classroom Scene in the Quartermaster Blacksmith and Welding School of Camp Lee's Army Service Forces Training Center

George D. Foulkrod, of Petersburg, Va., instructor at the school, is pointing out a diaphragm used to regulate the working pressure of an acetylene welding torch. The board contains a complete welding and cutting outfit.



U. S. Army Photo

Quartermaster Trainees at Camp Lee's Army Service Forces Training Center Learn All About Welding at the Blacksmith and Welding School

Above, acetylene welding is being performed by a group of students. Altogether in the shop are 48 acetylene welding stations.

to entering the Army. As an enlisted man he was at the Blacksmith and Welding School at Camp Lee from February to June 1941. In September of last year he was appointed officer in charge following service in Iceland, England and North Africa, serving with the Transportation Corps.

Training is provided at the school in blacksmithing, oxyacetylene welding and arc welding. Instruction is given in welding both ferrous and nonferrous metals. All welders receive two weeks' schooling in blacksmithing, four weeks in acetylene welding and two weeks in theoretical arc welding. Blacksmiths who show efficiency after six weeks are given two weeks' welding instruction.

The school's training program prepares Quartermaster soldiers for work in QM blacksmith and welding activities in base depots and repair shops overseas, as well as installations in this country. They do welding work on heavy equipment in the field, metal salvage and salvage reclamation, such as cutting up tanks, heavy guns and automotive equipment. They repair mobile laundry, fumigation and bath, and refrigeration equipment in the field, as well as field ovens, steel cots and bed frames, sewing, shoe repair and dishwashing machines, and cooking utensils.

Besides its training functions, the school is also one of production. Since 1941 it has performed 2503 jobs for various elements of the training center. The production jobs were of a miscellaneous nature, including the repair and welding of chains; straightening and welding of truck bumpers and frames; forging of all types of hand tools; production of all kind of special tongs; welding of trucks' axles, housings, exhausts and intake manifolds; repair of Engineer and Post laundry equipment, and manufacture of all types of tables, benches, brackets and special stands for training aids.

The instructors of the school have developed a system whereby they keep in touch with their graduates after they leave Camp Lee. Each is given a postcard with the return address of the school printed on it. On the back are blank spaces to be filled in telling where the graduate is, what type of unit he is with and what specific type of work he is doing. There is also room on the card for writing down suggestions for improving the course based on observations and experiences gathered after leaving the camp. The plan has been in operation several months, and cards have been returned from graduates in the Southwest Pacific, Australia, England and North Africa.

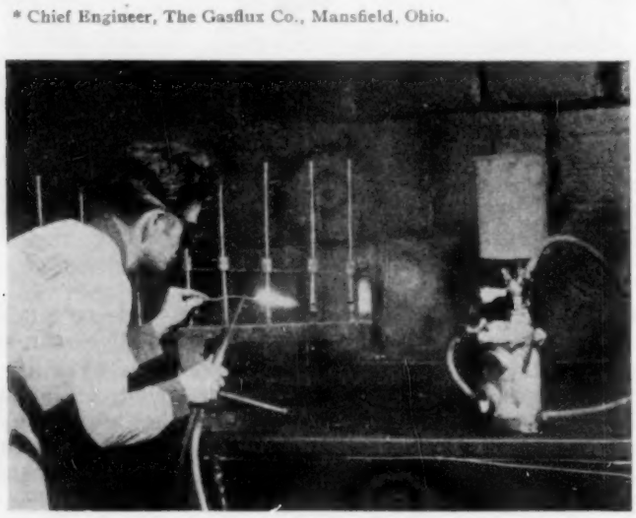
New Silver Soldering Technique Improves Production

By C. A. Medsker

DEVELOPMENT of a new technique for the use of silver solder and other low melting point alloys in production has practically eliminated the principal nonproductive finishing operations that have been common-place steps of procedure in numerous plants. The essence of the improvement is the automatic supply of flux to the joint in the correct amount and at a uniform rate.

Proper fluxing of the joint is more than incidental to the silver soldering process. It performs the vital function of dissolving and removing oxides and other impurities, and of inducing a rapid flow of the solder through the joint. Since failure to use sufficient flux inevitably results in a substandard joint, the tendency is to use more

* Chief Engineer, The Gasflux Co., Mansfield, Ohio.



Courtesy The Weatherhead Co., Cleveland, Ohio

Fig. 1—A Gasflux Installation for Silver Soldering in Production. The Flux Is Supplied Automatically Through the Flame

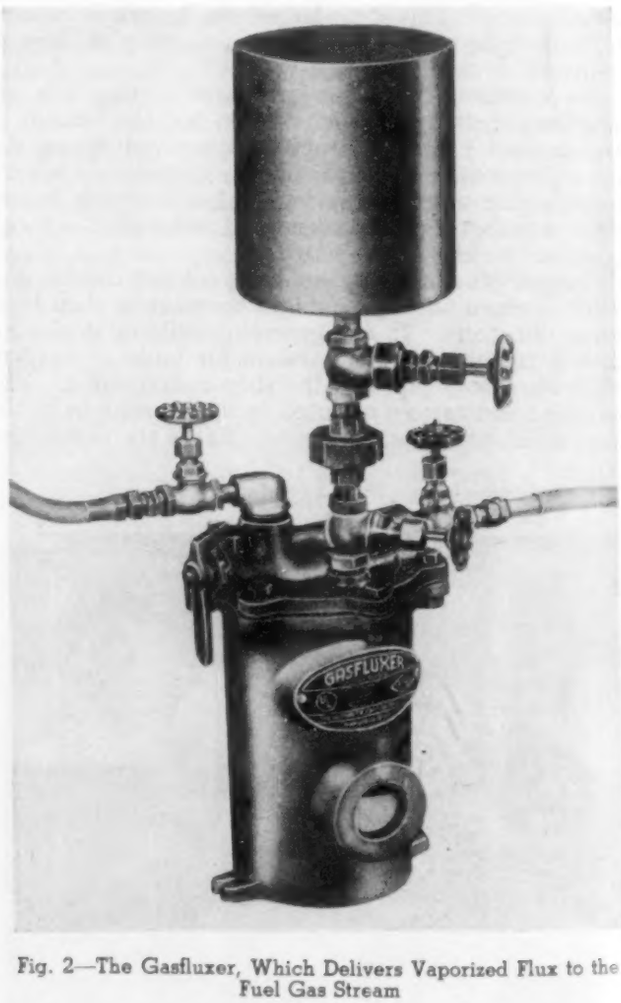


Fig. 2—The Gasfluxer, Which Delivers Vaporized Flux to the Fuel Gas Stream

Fig. 3—A Typical Application Is the Assembly of This Weatherhead Nonrechargeable Silica Gel Dryer and Filter for Use on Electric Refrigerators

than enough flux in order to be on the safe side. This is especially true of operators who have not had long experience with the process, and the war emergency has made it necessary to employ many of them after only a brief period of training.

Under these conditions two difficulties have been encountered, both of which are detrimental to the production rate. First is the discoloration and the accumulation of residue when excess flux is used. This means a special cleaning operation (usually washing with hot water followed by electrolytic cleaning or pickling), followed by grinding and buffing to remove all traces of the glassy residue. The second effect is the generation of porosities by the gases emanating from the volatilized flux. Where gas-tight joints are specified these porosities are usually discovered by prevailing inspection methods and the rejected parts have to be either reworked or discarded.

Some studies that were made of large scale silver solder operations in war production plants pointed to improper application of flux in paste form as the probable cause of these difficulties. Experiments were then conducted to develop procedures for using the automatic Gasflux process, which had been used successfully for several years for brazing and bronze welding operations. With a very little modification to accommodate local plant conditions these procedures are now being widely applied in practice.

In general, this process does away with the conventional method of dipping the filler rod into the flux or applying the flux to the work with a brush. The process consists of properly compounded fluxing ingredients carried in solution in a highly volatile and inflammable liquid which evaporates rapidly when exposed to the air. Equipment consists of a container called a Gasfluxer, which is introduced into the fuel gas line supplying the torch. The head of this container has a cylindrical flux regulating and by-pass valve which permits operation with any desired amount of flux or with no flux if used as a complete by-pass. The interior contains a cotton wick or filter which is kept saturated with the liquid. After turning on the fuel gas and opening the torch valve to allow all the air to be expelled from the system, it is ready to operate. The fuel gas passing through the apparatus picks up the flux in vapor form and delivers it to the torch in the gas. The flux is in the flame, instead of on the rod or on the work, and the proper amount to use can be secured by adjusting the flux regulating valve. The fuel gas may be acetylene, city gas or any other gas that is suitable for the conditions of the work; and no change needs to be made in either torches or tips. A reserve tank of 1-gal. capacity is attached to the Gasfluxer for convenience in refilling without stopping operations, and a sight glass on the bottom part of the container body provides for observation of the liquid level.

Presence of the vaporized flux in the fuel gas stream imparts a brilliant green color to the flame which tends to mask the inner cone. However, the flame structure can readily be seen with welding goggles, and therefore all adjustments of the torch are made while wearing welding goggles, which preferably are fitted with green lenses. Final adjustment of the torch should be made to give a mild brush-like flame, because a mild flame does not blow the filler metal away and gives a very smooth finished joint.

An important difference between using the process for silver solder and for brazing with the various copper base alloy rods is that with silver solders much less of the flux is used. There is no danger of missing any part of a joint because the flux is being supplied continuously through the flame.

For joints of the butt and fillet types the simple procedure outlined above is perfectly satisfactory. Lap and press fit joints (such as the tube within a tube type) necessitate a special technique because these joints usually present very little clearance between the members and it is important to get effective capillary action for a firm bond. Since the flame cannot positively penetrate the small clearance it is not possible to get proper fluxing action by the use of the flame alone and an auxiliary paste silver solder flux must be used as well. In this case the paste flux should be applied in only sufficient quantities to cover the surfaces requiring the capillary action. In the tube-within-a-tube type of joint the paste flux should be applied carefully and lightly to the female part of the joint.

No changes in fixtures or assembly procedures are necessary. The new procedure is recommended for use on any silver solder job where it is necessary to clean after completing the joint or where pinholes or porosity are giving trouble. Principal advantages so far reported are: faster production; elimination of discoloration and after cleaning; and elimination of pinholes and porosity.

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(*Continued from page 12*)

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Locomotives, Mine, Tires. New Tire Shop Serves 172 New

(*Continued on page 35*)

Rods of HAYNES STELLITE Alloys
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SCRAPER BLADES, shear knives, sprocket teeth, steam valves, and hot punches are examples of parts successfully hard-faced with HAYNES STELLITE cobalt-chromium-tungsten alloys. These alloys are available in three grades of hardness and toughness, and are high in resistance to abrasion, corrosion, heat, and erosion.

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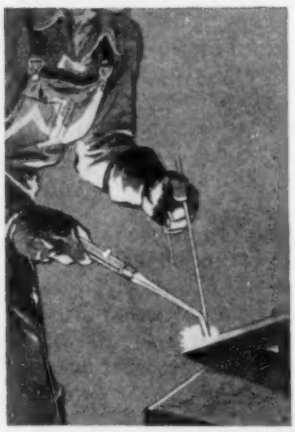

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Recent Applications of Oxyacetylene Processes in Steel Foundries*

By G. E. Bellew†

IN presenting this paper I hope to be able to present more than a review of the more widely known and used applications of oxyacetylene processes in steel foundries. It is recognized that many steel foundries employ the oxyacetylene flame for many diverse and sundry purposes; however, it is equally true that many foundrymen would be somewhat amazed were they aware of the potential economies at their disposal through a greater utilization of flame processes. By no means should this be construed to be an inference of criticism of the industry; on the contrary, it is only through the adoption of these progressive applications by a number of foundries that makes this paper at all possible.

As in all our industries, it required the impact of the present war to give us a true picture of our "bottlenecks" of production. Again in common with other industries, foundries found the road of double-quick transition to full-capacity production indeed a rough one—as rapidly as one problem was overcome, one or more new ones appeared.

In mass production of subassembly parts of war equipment, the delays encountered in readying the foundry facilities were troublesome but not serious because, as soon as the various departments were coordinated for all-out production, the castings began to pour out in tremendous quantities. When this point was reached, however, it became evident that the capacity to deliver castings was no longer dependent upon the rate of "pouring" but, instead, upon the rate of "finishing."

There were several causes for this condition. The long-accepted practices of finishing were of such nature that speedups were impossible. Some foundries properly evaluated the problems involved, and responded accordingly by searching for a solution that would eliminate or minimize these troublesome factors. It was against this background that, after looking over every conceivable possibility, these foundrymen turned to oxyacetylene processes—machine gas cutting of risers, flame gouging, scarfing and descaling—to speed up and improve the finishing operations. The positive effects of this measure reached into all phases of the problem—a far greater production per man-hour was attained, finishing "bottleneck" reduced or eliminated and costs per casting lowered. The net result was the change of complexion of the finishing department from one of "overhead" to one of "integrated production."

As pointed out in a previous paragraph, the repercussion of the war on industry was greatly responsible for many of the new methods introduced in the foundries. In a war as complete as this one, no one has been able to escape the fact that there is a vast difference between a war-economy and a peace-economy. However, some factors continue in a fairly straight line through both, particularly in the more basic phases of industry, for example, overhead costs, material costs, labor costs and, importantly, several intangible costs, such as good will and reputation from prompt deliveries of products. The appearance of these and other factors in both economies reveals the reason for the inevitable carry-over of new techniques and methods into normal production from war production. These new methods were originally introduced for the sole purpose of increasing production but as increased production is related to lower unit costs, it is difficult to see how foundries using older methods can possibly compete economically with the forward-looking foundries after the return to normal operations.

It is to the interest of all foundrymen that their business compare favorably in state of health, progress and vitality with industry as a whole. It is the intent of this paper to present new or improved developments that can enable the foundries of the country to maintain—or if they choose, to improve and strengthen—their position in the postwar array of industry. A prerequisite of any state of industrial health is the survival of small concerns in the over-all picture; however, the small operator has discovered that his continued existence has become increasingly more difficult. To him, the new applications of oxyacetylene processes will prove of unique good fortune, since he can acquire the same means of efficient operations as the larger foundries at a

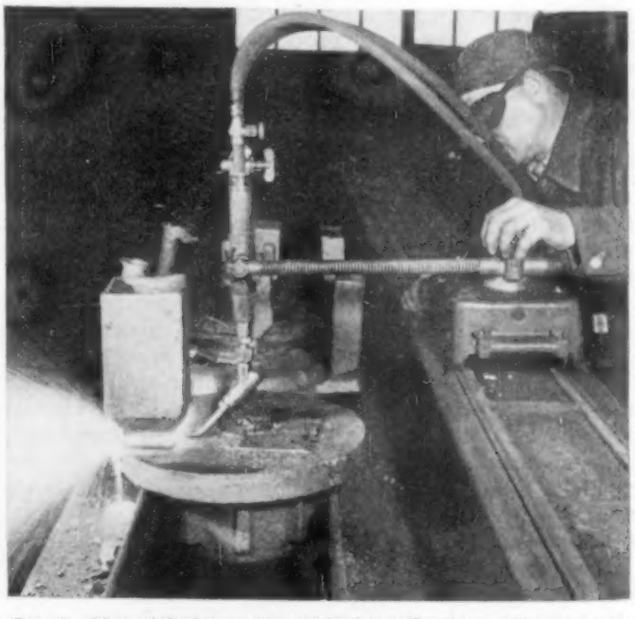

Fig. 1—Use of Radiagraph in Machine Cutting of Risers and Pouring Gates. Castings Rest on Two Adjustable Angle Bars Parallel to Machine Tracks

* Presented at the Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16–19, 1944.

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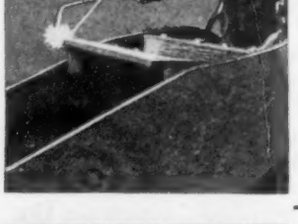

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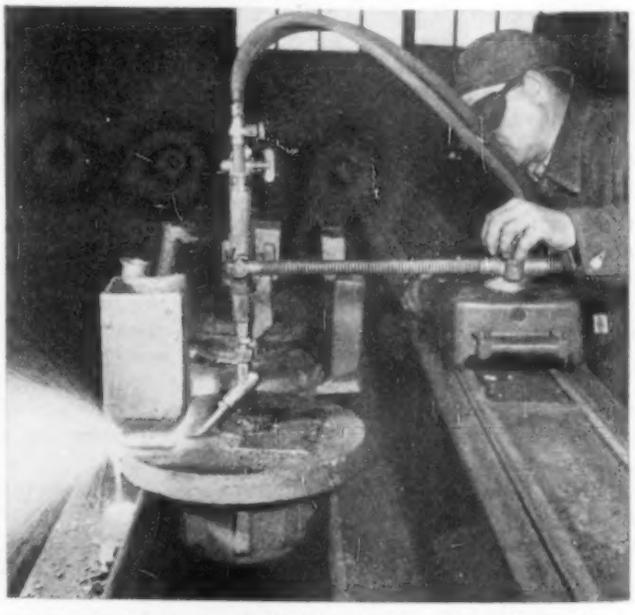

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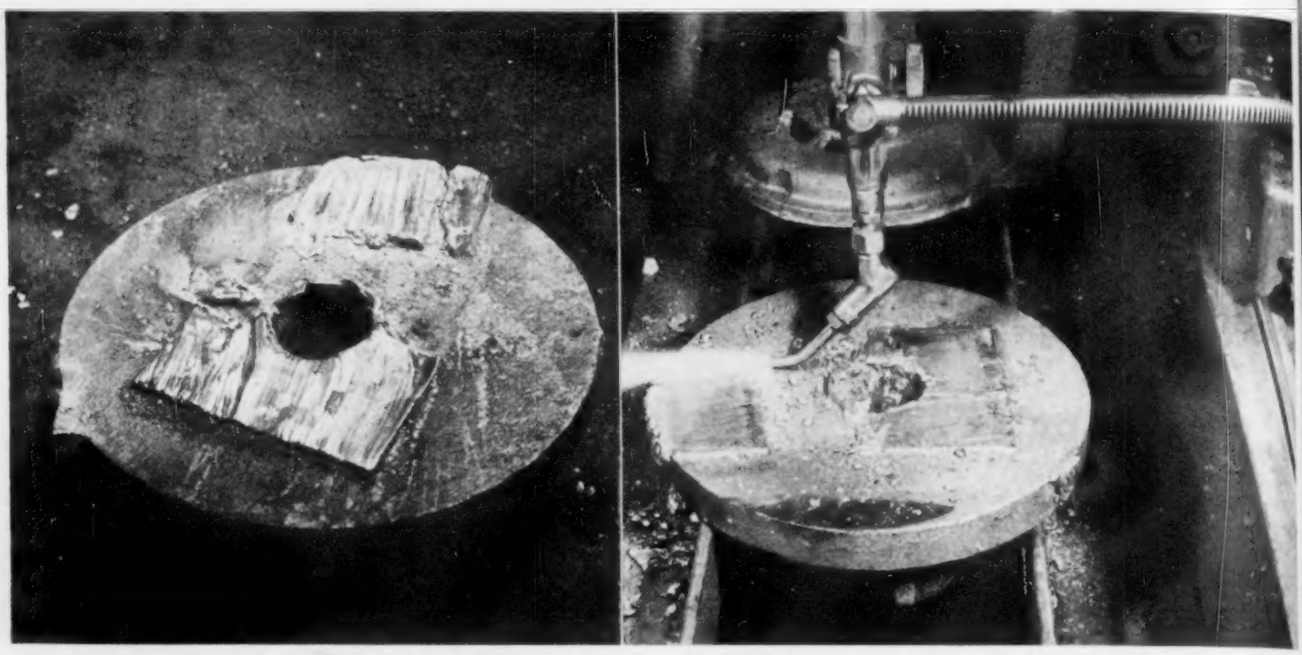

Fig. 2 (*a*) Fig. 2 (*b*)

Fig. 2—Contrast in Appearance of Identical Castings After Risers Have Been Cut (*a*) by Hand and (*b*) by Machine. Note the Excess Metal and Gouges of Hand Cut and the Smooth, Clean Cut of Machine Torch

cost so small as to be easily absorbed by the decrease in costs of production.

In foundries, large and small, the oxyacetylene process will be found to strike directly at one of their gravest problems—the size of the cost-time factor in the finishing of the castings. This solution will provide a twofold answer; the ability to make more rapid deliveries of castings and the ability to withstand the intensified competition of the future.

Machine Cutting

The machine torch has been introduced to replace the hand torch in the cutting of risers. From the response of those who have tried the machine, it seems destined to attain an even greater acceptance than that accorded the hand torch. The new process makes possible a cut smoother, straighter and closer to the surface of the casting, thus reducing the amount of grinding required by a very significant degree.

Other Advantages

Machine flame cutting is somewhat faster than hand torch cutting since the machine always runs at its maximum speed for a given operation while the human element renders this impossible in hand cutting.

The machine torch does not lead to fatigue of operator and its inevitable loss of speed and efficiency.

Women can handle the work as easily as men.

Much less training is required to operate the machine torch. Operating expenses are lowered considerably; grinding wheels are costly, consequently, reduction in grinding means appreciable reduction in costs.

The "filling in" of the inadvertent surface gouges made by the hand torch operator is eliminated as the machine torch avoids these under proper setup.

The problems of riser removal by the hand torch have not been confined to the factor of severance, but also to those of the elimination of the irregularities of hand cutting—the grinding off of the material remaining above the face of the casting, and the building up of areas below the face of casting; if this welding is to be avoided, the line of cut is necessarily kept at such a distance from the casting that the required amount of grinding is increased proportionally. This fact has made it evident to every foundryman that the time spent on the final grinding was 5 to 20 times greater than that spent on the actual cutting operation.

Some idea of the saving in costs effected by the new method may be gained from a report of a recent time study conducted on gear blanks with the expressed purpose of comparing the merits of hand cutting with that of machine torch cutting. To put the newer method to a severe test it was decided to let a highly skilled hand torch operator compete with a machine operated by an inexperienced hand. The hand torch operator, out to "beat the machine," made a fast close cut—slightly outdistancing the machine. The cut made by the machine, however, was smooth, straight and close to the surface of the casting. However, after the grinding was completed and the gouges made in the surface of the casting by the hand torch operator had been filled with weld metal, the time study proved that the machine cutting method was 29% more efficient than the hand cutting method.

In addition, the burden on the grinding department was lightened considerably by the machine cut: 5.35 min. of grinding on the machine cut as compared to 11.43 min. on the hand cut. An important consideration in this instance is the fact that the grinding after the machine cut could have been almost entirely eliminated if the foreman had not wished to leave a comfortable margin of safety between the cut and the surface of the casting.

One salient fact emerging from any comparative study of hand torch and machine flame cutting is the unique nature of the advantage of the latter over the former. Ordinarily, cost savings, improvements in quality of product and increases in production are separate, distinct factors by which are measured the relative advantages of alternate processes. Normally the various factors are of inverse or reciprocal relation, that is, the emphasis of one or more of the factors can be done only at the sacrifice of the others; however, in this case all the

Fig. 3—Using a Radiagraph to Cut Heavy Riser from Casting, the Woman Operator Adjusts Torch Position with One Hand as Cut Progresses

elements vary directly in their relation with one another. In other words, the real saving in both time and cost proceeds directly from the improvement in quality of cut. The advantages of machine flame cutting appear to increase in direct ratio to the size of the risers removed.

The enthusiasm with which machine flame cutting of risers has been received in the foundries is adequately attested by the large number of foundrymen who have, when necessary, taken the time to make considerable changes in their riser designs in order to accommodate the cutting machine to the highest possible degree.

Machine flame riser cutting setups generally fall into two classifications: straight-line and circular.

In the straight-line setups, a Radiagraph travels along a straight track to make the cut. Figure 1 illustrates this principle. In this instance, the castings are held in position by simply resting the shoulders of the casting on two adjustable longitudinal angle bars with the protruding center of casting hanging down between these supporting angle bars, this places risers in a position to be cut off cleanly at a line near the face of casting. The machine moves progressively along the track from one casting to the next, and for quantity production a helper

Fig. 4—Riser Being Cut from a Large Inverted Casting by the Use of a Radiagraph Guided by a Radius Rod Attached to a Center Point

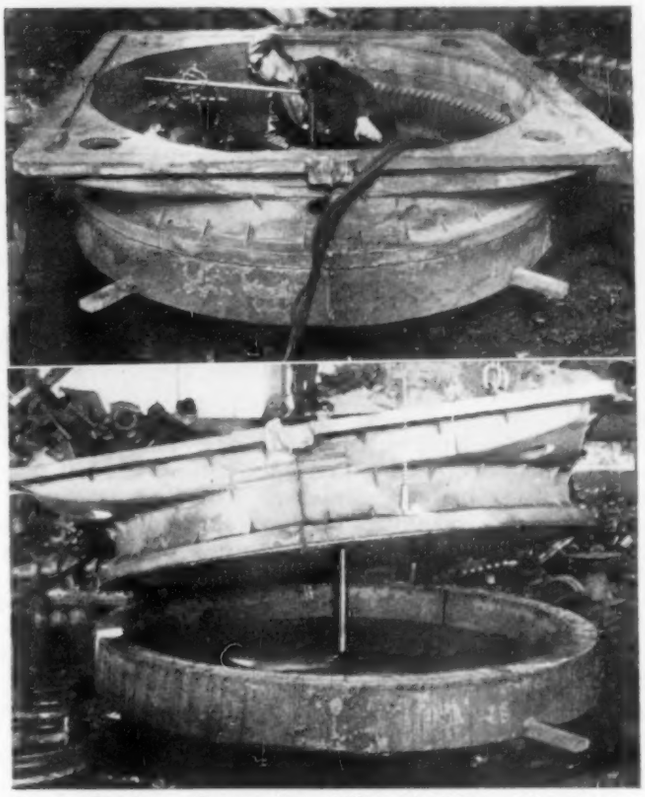

Fig. 5—The Large Casting (Fig. 4) Hoisted Off Riser After Separation to Show the Smooth, Clean, Square Cut. The Cutting Operation Required Only 65 Min.

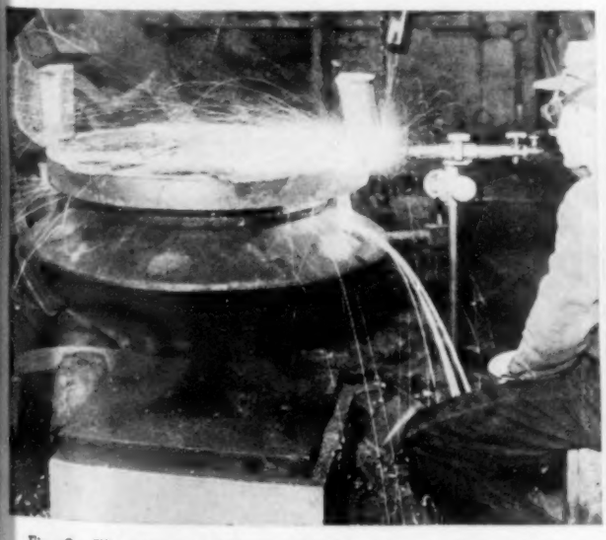

Fig. 6—Illustration of Turntable Setup, with Gear Blank Rotating Past Fixed Torch. This View Shows the Removal of Risers by Cutting in Horizontal Plane

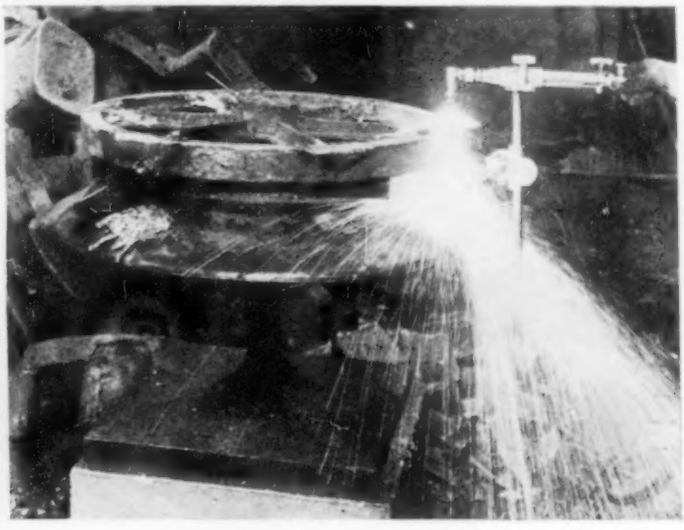

Fig. 7—Same Operation as Fig. 6, Except Cutting Done in a Vertical Plane in the Removal of Pads

Fig. 8—The Gear Blank (Figs. 6 and 7) After Cutting Operation Has Been Completed. Note the High-Quality Cuts in Both Planes—Very Little Grinding Required

can be employed to remove finished work and set up a line of fresh castings while cutting is in progress.

A distinct advantage may be noted in the use of the machine for cutting the risers from this and the many similar types of castings—the cutting of other risers without a change in the position of the machine or casting. The torch tip is adjusted horizontally by means of a handwheel on the machine to the proper starting point for the cutting of the second riser.

Figure 2 illustrates the contrast in quality of the cut of hand cutting and machine cutting. On the left, the risers have been cut off by an experienced operator using a hand torch; on the right, the risers have been removed by a flame cutting machine. The importance of difference is obvious; the hand cutting has left considerable metal above the surface of the casting, requiring a large amount of mechanical grinding, and also the metal has been gouged out below the face of the casting requiring it to be built up by welding.

The advantage of machine cutting risers increases sharply when the risers run the full length of the casting. Figure 3 illustrates this case. The machine travels at approximately 6 in. per minute, cutting with an oxygen pressure of 65 lb. The curvature of the casting is compensated for, as the cutting progresses, by adjustment of the handwheel on the torch mount. Incidentally, this woman operator was brought in totally unskilled

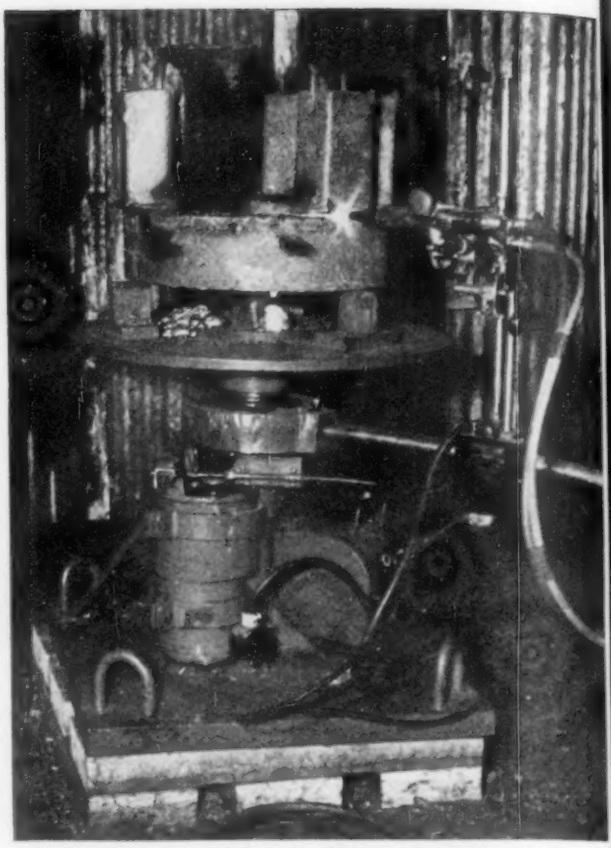

Fig. 9—Illustration of Circular Setup with Torch, Attached to Radius Rod, Rotating Around Fixed Casting. These Gear Blanks Required No Further Finishing Before Shipment

but it required only one day to become thoroughly familiar with this operation, proving the relative simplicity of machine cutting over hand cutting.

These castings are turned out in fairly large quantities; therefore, the grinding operation would have been tremendous if the risers were cut by hand; however, the machine cuts are smooth enough to be acceptable without further treatment, thus the grinding operation has been eliminated entirely.

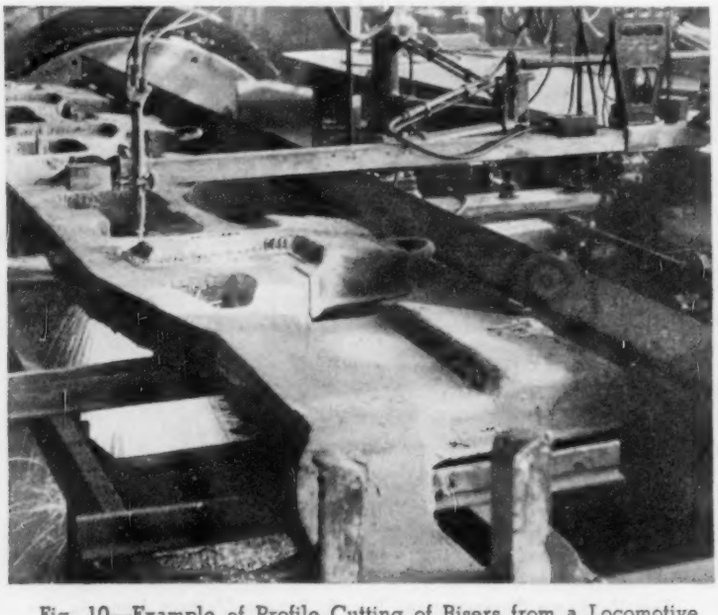

Fig. 10—Example of Profile Cutting of Risers from a Locomotive Side Frame. Note the Even, Narrow Kerf, Making Possible High-Quality, Precise Cutting

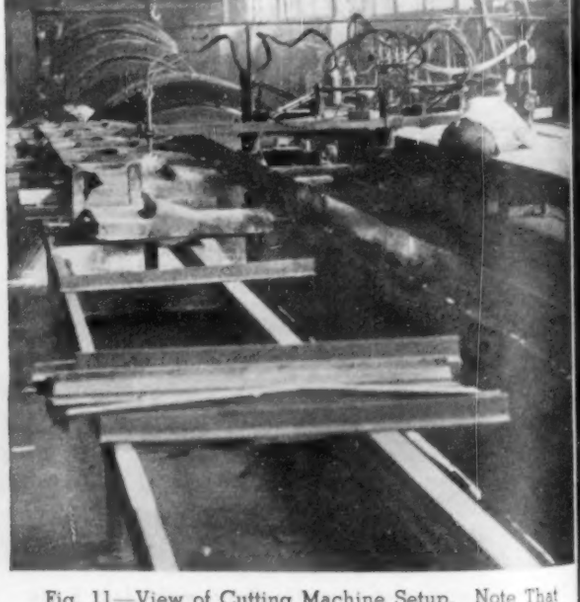

Fig. 11—View of Cutting Machine Setup. Note That During Cutting Operation, Operator Can Give Full Attention to the Template and Tracing Device

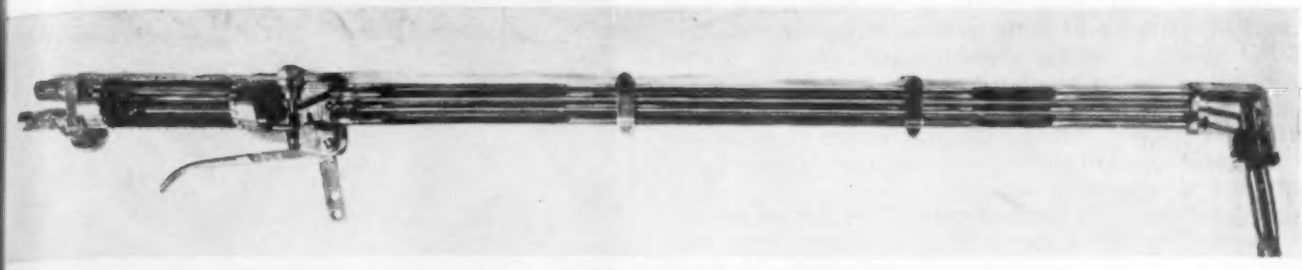

Fig. 12—Standard Scarfing Torch

Fig. 13—A Typical Scarfing Operation. In This Case, 60 Lb. of Metal Were Washed Off, Reducing Grinding Time 35%

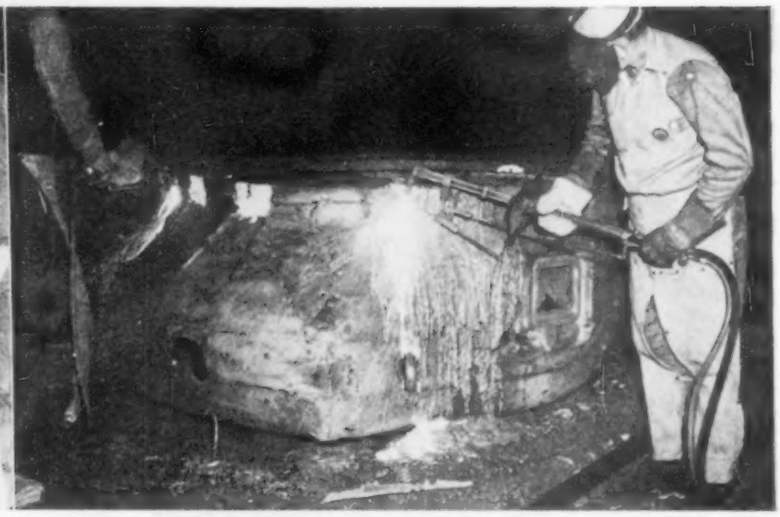

Fig. 14—A Two-Man Scarfing Operation Requiring but 20 Min. to Remove 40 Lb. of Metal from an Area of 1180 Sq. In. Saving 2 Hr. in Finishing Time

Circular setups may be subdivided into two groups: those in which the torch travels around the work and those in which the work rotates around or past the torch.

Figure 4 illustrates a type falling into the former group; this shows a circular riser being cut from a large inverted casting by the use of a portable Radiagraph guided by a radius rod attached to a center point. The machine cuts through the 5-in. wall thickness at a speed of 5 in. per minute—the entire operation taking only about 1 hr. and 5 min. In Fig. 5 the very high quality of cut can be seen as the casting is lifted off the riser. The cut was sufficiently smooth, square and close that no grinding was required for finishing.

Of the circular setups, the group in which the work rotates past the torch can be represented by Fig. 6. This photograph shows a gear blank casting with six risers, the risers being so located to require cutting in both horizontal and vertical directions. The horizontal cut is shown here, with the casting rotating on the turntable, placing each riser successively at cutting position.

Figure 7 shows the riser pads being removed by vertical cutting. This dual-directional cutting does not require a change of setup either of casting or of cutting machine other than replacing straight tip with bent tip. The raising or lowering of the torch is taken care of by simply turning handwheel on torch mount.

Figure 8 shows the casting after complete riser removal. In this case the requirements called for flush grinding on all surfaces; however, clearly very little grinding is required. The grinding time for all 12 faces of an identical casting cut by hand torch was 5.4 min., with additional time spent making several weld repairs where the torch had removed metal below the surface of the casting.

Figure 9 illustrates another setup for the flame cutting of risers from gear blank castings. This example differs from the above mentioned in several respects. Here the cutting torch revolves around the fixed casting; the floating torch and mount is supported by a radius-rod centered on the vertical axis of the casting. The pads at the foot of each riser—discernible in the picture—have been added in order to obtain a cleaner, smoother cut.

The somewhat rough appearance of the casting is caused by the slag produced by the flame cutting. The condition of the casting was sufficiently good after the removal of the slag that, except for a little polishing by a portable grinder, no further finishing was necessary before shipment. The time required to remove all the risers by machine cutting was from 12 to 15 min. including the time required for handling casting. This company found that the required grinding was reduced by 90% through the replacement of the hand torch by the machine torch for the cutting of risers.

The cutting time of the $4^1/_2$ x 8-in. gear blanks for the machine was 7 min. per casting compared to 22 to 25 min.

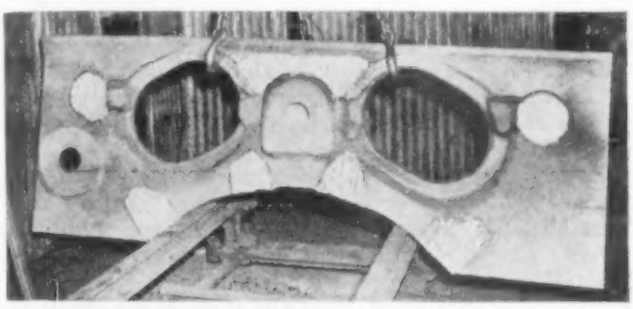

Fig. 15—A Casting After Scarfing. The Operation Required but 48 Min. to Remove 80 Lb. of Metal and Reduced Grinding 56%

required by hand torch. Both speeds were based on an acetylene pressure of 5 lb. and an oxygen pressure of 45 lb.; however, on the speed-test run, the experienced hand cutter used a regulator-oxygen pressure of 90 lb., claiming he further reduced the pressure at the torch by the torch trigger. Obviously, this either gave unduly unfavorable speed of cutting or a very uneconomical consumption of oxygen, or both.

The advantages of machine cutting are not confined to increased efficiency of the cutting-off of risers from castings; thus far, this discussion has emphasized the speed and close-tolerance characteristics. Now, a process

Fig. 16—The Scarfing of a Smaller Casting—Operator Is Removing Pads and Sprues from a Cast Ship-Cleat

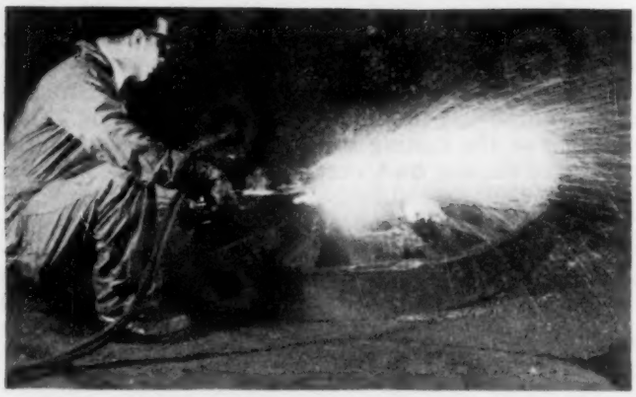

Fig. 17—Superficial Metal Being Removed from a Locomotive Wheel by Scarfing

involving a more extensive application of the principles of flame cutting is presented—that of profile cutting. This process has come to the attention of foundrymen so recently that its utilization has been limited to several notable cases.

Profile cutting, in its application to the finishing of castings, is actually equivalent to the "cutting-out," rather than the normal "cutting-off," of risers and has proved to be of particular value in large castings of intricate design. Figure 10 illustrates this operation; here a riser is being cut from the 6 in. locomotive side frame casting. It may be noted that the riser is not merely a block of metal attached to the upper part of

Fig. 18—The Locomotive Wheel (Fig. 17) After Scarfing; the Casting Now Requires Just Enough Grinding to Erase the Shallow Scarf Lines

the casting but, instead, extends to nearly the full depth of the side frame. This is not a novel way of pouring castings, as the side frames as well as many similar types, have previously been so cast; however, in the use of the hand torch to cut away the riser, the finishing job has always been a long, difficult and uneconomical task.

Many of these disadvantages have been eliminated through the utilization of the flame profile cutting process. In Fig. 10, the clean, square, smooth cut can be observed. The cut, being of narrow and constant width, can be accurately maintained near the line of final profile of the casting. The success of the operation is due to the exactness by which the torch (and thus the cut) can be guided by the Oxygraph or Travograph cutting machine.

Figure 11 shows the mechanical equipment and setup of the Travograph. The operator at the right is watching the tracing device follow the outline of the template that, in turn, controls the movements of the torch; ob-

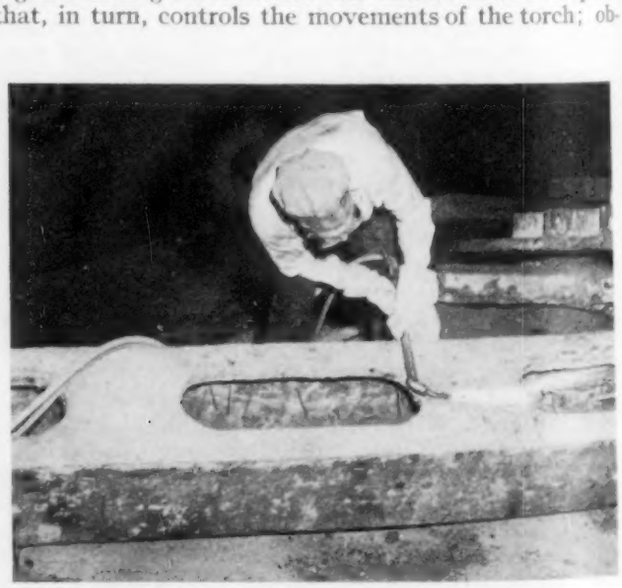

Fig. 19—The Gouging Out of a Defect in an Open Hearth Back Wall Buck Stay. This Operation Required Only 2 Min. Compared with 15 Min. if Removed by Chipping

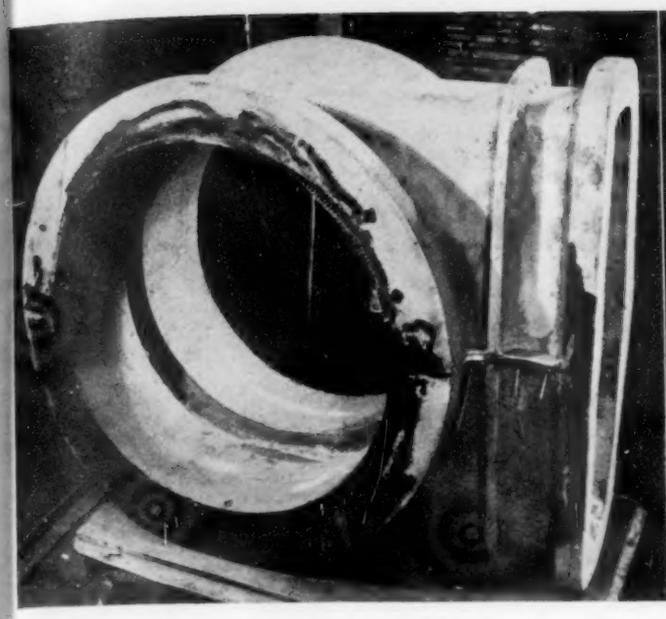

Fig. 20—A High-Pressure Gate Valve with Defects Indicated by Chalk Marks

Fig. 21—Operator Removing Defects by Gouging; the Entire Operation Required Only 33 Sec.

viously the cutting phase of the operation is dependable and automatic as it does not require the attention of the operator.

The template, lying on the table directly in front of the operator, is cut from $^1/_4$-in. sheet metal to the final shape of the casting. Through the pantographic construction of the machine, every movement of the tracing device is transmitted instantly to the torch, which accurately follows the movement of the device. In this way, the final pattern of the casting is trimmed from the rough casting by simply allowing the torch to be guided by the template and tracing device.

There are several distinct and notable advantages in this machine operation. A superior, sounder casting can be assured by the use of the type of riser shown in Fig. 10 as it greatly facilitates the flow of molten metal to developing cavities of the casting during the period of cooling, particularly in the lower regions of the casting. The accuracy obtainable by the Oxygraph and Travograph, reduces the amount of grinding required on the casting to an enormous degree; in fact, in many instances, subsequent grinding is not required. As these advantages are contrasted to the old method of finishing these castings, with its long, expensive and difficult finishing operations, the efficiency and expedience of the new, profile-cutting method are readily apparent.

In the case of the locomotive side frames, the riser cutting involved 600 linear inches at a speed of 6 in. per minute. The total time of cutting was 1.7 hr. per frame, with the operation reducing the weight of the side frame from 7000 to 5500 lb. By the old method using a hand torch, the riser cutting required 10 man-hours; however, utilizing the profile-cutting process, the same work was done in less than 2 man-hours. A factor of even greater saving obtained by the application of the latter method was the extremely large reduction in grinding; unfortunately, however, no figures are available on this operation.

Scarfing

Another oxyacetylene process which has recently been applied with great success in steel foundries is that of flame scarfing. Scarfing is a variation of flame cutting, in which only the surface metal is removed. Here again, the chief advantages are that a great deal of grinding is eliminated, and that considerable time is

Fig. 22—Removal of Defect in Railroad Coupler by Gouging

Fig. 23—Characteristic Gouge Lines on Third and Fourth Coupler from Left. Coupler on Right Has Been Repaired by Welding After Gouging Out Defect

saved. The best application of flame scarfing is the removing of riser pads and riser stubs after the riser itself has been removed. The application of scarfing for these operations has been found to be half again as fast as the carbon arc in washing away the excess metal, and approximately fifty times as fast as grinding. The scarfing torch, shown in Fig. 12, in the hands of a skilled operator, leaves a smooth, bright surface, making finish grinding almost unnecessary.

A factor of prime importance in the utilization of scarfing is the general adaptability of the operation in respect to location of the casting. It is unnecessary to move the casting from one department to another or to shift it to a worktable, since the hand scarfing torch can be brought to bear on the casting in any location.

In one instance the scarfing torch was used to wash away the stub which was left after cutting off a large sinkhead from a 25,000-lb. ship anchor. The entire job of cutting and scarfing was done in 30 min. Previously the same job had taken 45 to 50 min., using the carbon arc to wash away the excess metal after the manual torch cutting of the sinkhead. The difficulties presented by the contour of the casting encountered in this case were similar to those described below.

Another example, even more interesting, is the case where a large casting had a sinkhead 4 in. high and about 15 in. square. Because of the shape and size of the casting it was impractical to use a cutting torch in the usual manner, consequently the foundry had been removing the sinkheads by slicing off sections of it with a hand torch, and then melting away the remaining metal with a carbon arc—a long and tedious process. Now the job is done in 10 min. by scarfing off the entire mass of the sinkhead, roughly 1000 cu. in. of steel.

From these examples it will be seen that the application of the flame scarfing process on steel castings offers a means of cutting hours off of finishing schedules, and of cutting costs proportionately.

A typical example of scarfing is illustrated in Fig. 13; the operator is shown using a 36-in. scarfing torch, with 75° head and starting rod attachment, to wash away riser stubs. Under the old method of finishing such castings, the riser was cut off by hand torch, then the riser stub was trimmed as nearly flush to face of casting as possible and, finally, completed by grinding. Under the new scarfing method, the riser is cut off by hand

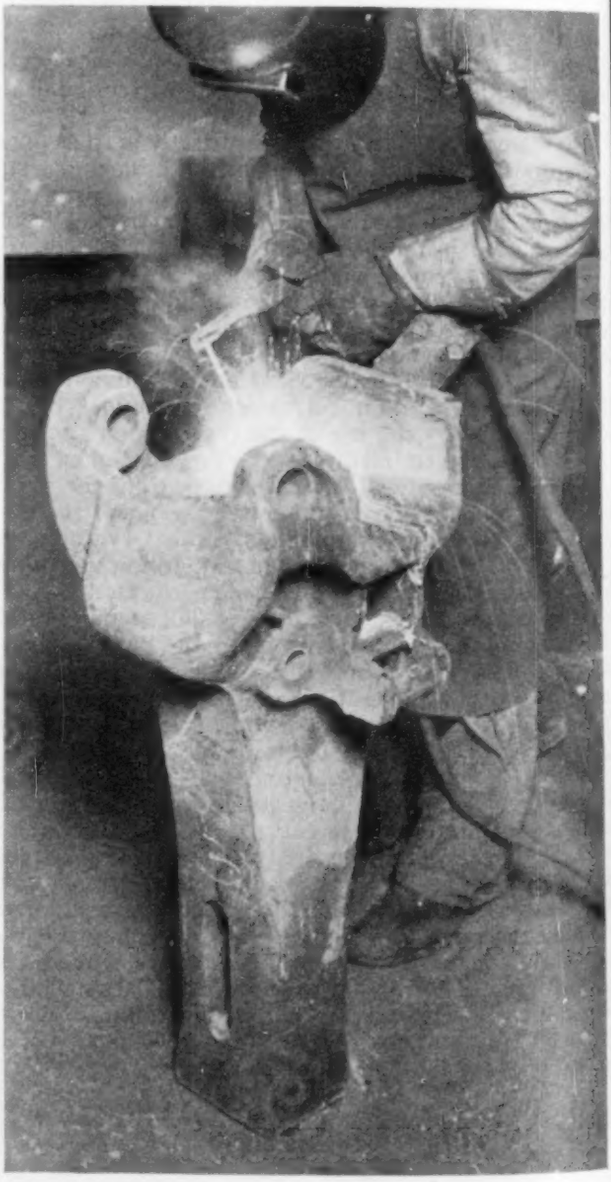

Fig. 24—Repair Welding after Gouging Operation. The Completed Weld Can Be Seen at Extreme Right in Fig. 23

torch, and the excess surface metal is then washed away by the scarfing flame, entirely eliminating the trimming procedure.

In the case shown, by the application of the scarfing process, using an oxygen pressure of 75 lb. and an acetylene pressure of 5 lb., 60 lb. of metal were washed off, that under the old method, required removal by grinding. After scarfing, only 10 lb. of metal remain to be removed by grinding, making possible a saving of 30 min., or 35% in grinding time.

Figure 14 shows another application of scarfing. Here, again, 36-in., 75° head scarfing torches are used to wash away riser stubs. Prior to the adoption of the scarfing process, these castings were trimmed by a cutting toch. By the latter method, the operation required 20 min. for the trimming of 40 lb. of metal from an area of 1180 sq. in., followed by 3 hr. of grinding. Since employing the scarfing process, the grinding time has been reduced to 2 hr., representing a saving in grinding time of 35%.

Figure 15 represents a typical casting after removing considerable excess metal by scarfing still remaining on the casting. The operation was accomplished by the use of a 36-in., 75° head scarfing torch, with an oxygen pressure of 80 lb. and acetylene pressure of 4 lb. The scarfing process was used to remove 80 lb. of metal that previously were removed by grinding, thus reducing the grinding time 56%, with the scarfing operation requiring but 48 min.

Figures 16 and 17 illustrate the wide range of application of the scarfing process. The former shows the operator scarfing the pads and sprues from the cast ship-cleat. After the operation was completed, the scarfed surface was almost flush with the final surface, leaving very little for grinding. In the latter photograph, the superficial metal is being removed from a locomotive wheel. In Fig. 18, the casting is shown after the operation; obviously, little grinding is necessary—just enough to erase the very shallow lines left by the scarfing torch.

Gouging

Another oxyacetylene process, which can be used to speed finishing operations, is that of flame gouging. This is also a variation of flame cutting, and, like scarfing, is used to remove excess surface metal. In contrast to scarfing, where a torch of special design is used, gouging may be accomplished by the use of the standard hand cutting torch, fitted with a gouging tip.

The purposes for which gouging was designed are the removal of webs and fins from castings, and in gouging-out defects. In general, gouging is a substitute for chipping and is at least seven times as fast. This means, of course, tremendous savings in time and man power, since one torch operator can do the work of as many as ten chippers. For a concrete example, in one foundry all the webs on a huge casting were removed by flame gouging in 45 min., whereas the identical job, previously done by pneumatic chipping, required $2^1/_2$ days. This is an extreme comparison, and not all jobs have this great differential; however, every job has proved that flame removal of metal greatly exceeds the rate possible by mechanical removal.

In burning out defects in castings, the gouging process has one important advantage in addition to its speed. This is the impossibility of covering up a defect, or a portion of a defect, during the removal operation. With mechanical chipping, at times part of a defect remains in the casting after the cavity has been filled by welding.

The number of foundries using gouging is not yet large, but several studies have been made. In one, actual tests on light and medium castings of low-carbon steel proved that gouging was seven times as fast as chipping, the average gouge was about $^3/_8$ in. deep, $^3/_4$ in. wide and 3 in. long, with a time of operation of 3 min. The foundries have also found gouging to be a particularly efficient method of trimming off the fins of extruded metal which sometimes creep into the space between the two halves of the mold.

Figure 19 shows an operator gouging out the defect

Fig. 25—Operator Gouging Out Defect from a Truck Side Frame of a Railroad Freight Car

Fig. 26—Typical Flame Descaling Operation on High-Pressure Gate Valve

in an open-hearth back wall buck stay. The completed gouge, 12 in. long, $1^3/_4$ in. wide and $1^1/_2$ in. deep, was made at a speed of 6 ft. per minute using an oxygen pressure of 60 lb. and an acetylene pressure of 8 lb. The entire time consumed in the gouging operation was approximately 2 min. compared with 15 min. required to remove such a defect by mechanical chipping.

Figure 20 shows a 30-in. high-pressure gate valve with defects indicated by chalk marks. Figure 21 shows the operator using a bent gouging tip to remove the defective metal from the casting. In this case, it was of particular advantage to utilize the flame-gouging process in repair of the casting since the valve, after installation, was to be subjected to extremely high pressure, consequently, if a defect were to remain in the valve—as can happen under mechanical chipping—a constant danger of rupture would result.

The defects indicated in Fig. 20 required two gouges, one $1^1/_4$ x $^3/_4$ x $^1/_2$-in. depth and one 10 x $^3/_4$ x $^1/_2$-in. depth. The time required for the entire gouging operation was 33 sec. using 45 lb. oxygen pressure and 6 lb. acetylene pressure.

Figure 22 shows the gouging out of a defect in a railroad coupler. In Fig. 23, characteristic gouge lines can be seen in the third and fourth couplers (left to right). Figure 24 shows the repair welding of the coupler shown in Fig. 22. In reference again to Fig. 23, the repaired coupler is shown at the right. After the complete operation, the casting is perfectly sound and capable of withstanding the terrific impact and stress given the coupler in service.

Figure 25 shows the gouging-out of a defect in a truck side frame of a railroad freight car. After the gouging and repair-welding operations, the casting can be heat treated and placed in normal service without fear of subsequent failure at the point of repair, and thus, the total loss of casting has been avoided.

Flame Descaling

A fourth oxyacetylene process that has been introduced to foundry operations is that of flame descaling. In this process, annealing furnace scale is flaked off castings by "brushing" the surface of the steel with the high-temperature flames. The resulting rapid expansion of the scale causes it to separate itself from the relatively cold base metal through the principle of differential expansion. The scale splits and spalls off, leaving a clean, exposed surface. This process is, again, much faster than chipping with a blunt-nosed chisel, and provides a cleaner surface, since all nonadherent scale is removed in one, or at most two applications; whereas, with chipping it is virtually impossible to secure complete removal of all scale unless the chipper spends an unreasonable length of time on each casting. As is gouging, flame descaling has the great, though intangible, advantage of eliminating the deafening clatter of the mechanical chippers, thus reducing fatigue and strain of the employees. A feature of decided importance to the health of the employees is that flame descaling does not fill the air with dust-like particles of metal scale which are injurious to eyes and lungs.

Flame descaling does not mar or, in any manner, act upon the surface of the base metal, however, some heat passes into the surface regions of the casting, and thus, where painting is to follow, the surface is dehydrated, making possible an intimate bond between paint and base.

It should be observed, however, that the process has definite limitations in one respect; the scale will not spall off the casting if sand is intermingled with the scale. Under these conditions, the hot flames tend to melt the entrapped sand, and, thus, increase the adhesion of the scale.

Fig. 27—The Flame Descaling of a 12.5-Ton Anchor

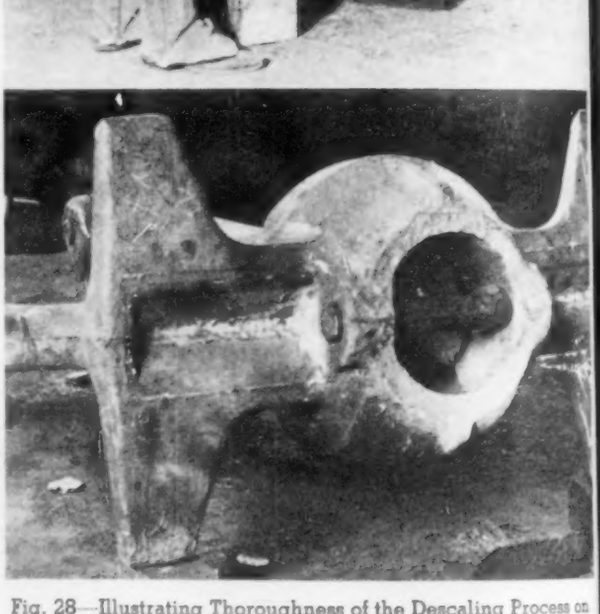

Fig. 28—Illustrating Thoroughness of the Descaling Process on the Anchor Shown in Fig. 27. The Operation, Involving 2100 Sq. In., Required Only 15 Min.

A typical flame descaling operation is shown in Fig. 26. While this process is considerably easier, cheaper and quicker than chipping in the descaling of small castings, these advantages are greatly mangified in its application to large castings. In the case of this large high-pressure gate valve, the relative ease of the flame process can be readily contrasted to the difficulties, fatigue and time involved were the descaling to be accomplished through chipping. This is especially true in regard to the inner and irregular surfaces.

Figure 27 shows the flame descaling of a 25,000-lb anchor; this illustrates the great advantage of the flame process in the finishing of large, massive castings. Here it would be impractical to move the anchor for "positioning" to facilitate chipping, consequently it would prove to be extremely uneconomical and cumbersome

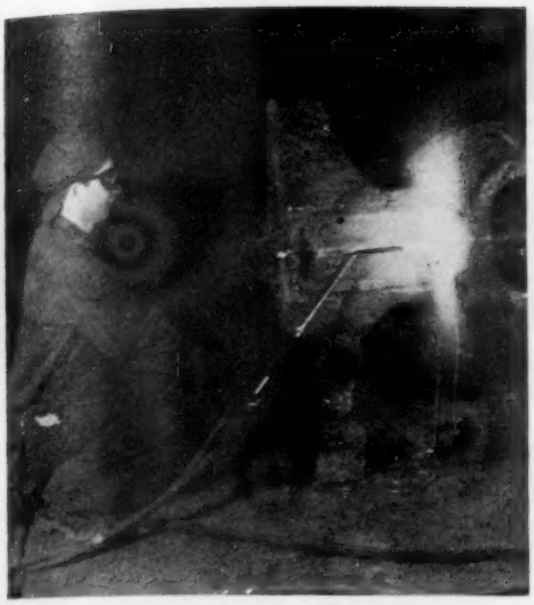

Fig. 29—Heating the End of the Anchor Connecting Pin by an Oxyacetylene Flame Before Peening. This Process Avoids Heating the Center Portion of Pin

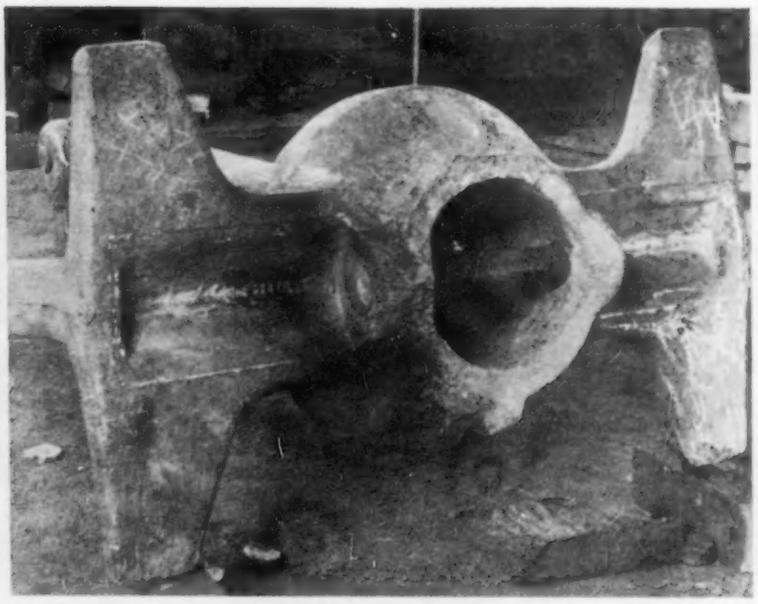

Fig. 30—Anchor After Peening Operation. Note the Complete Absence of Buckling of Pin Since Center Remains Relatively Cool

The descaling of the 2100 sq. in. area was accomplished in 15 min., permitting the finishing of 60 castings per day. In this instance, production was being retarded by the limited capacity of the shot-blasting department; however, through the installation of flame descaling equipment, the shot-blast operation was reduced 50%, thus doubling production. Previously the shot blasting required 30 min., however, through flame descaling, this was reduced to 15 min., with the complete elimination of wire brushing. Figure 28 shows quite distinctly the thoroughness of the finishing process.

Flame Heating

Flame heating was another oxyacetylene process utilized by the same foundry for efficiency and expediency in the production of the heavy anchor. A 5-in. diameter, 20-in. length connecting pin was rigidly affixed to the top of each anchor by peening $1^1/_2$ in. at each end of the pin. Prior to the adoption of oxyacetylene heating, the pin had been furnace heated; this had proved both costly and troublesome, as 30 min. were required to bring the pin to a red heat and, upon peening, the pin would buckle at the center. These difficulties were completely eliminated by heating the pin at each end with an oxyacetylene flame as shown in Fig. 29. The time required for heating was reduced from 30 min. to 6 min. and, as can be seen in Fig. 30, the relatively unheated portion of the pin between the ends easily withstood the buckling action produced by the end thrust. The net result of the newly established process was the increase in the capacity of the department to a point equal to that of the over-all production of the foundry—approximately 60 anchors per day.

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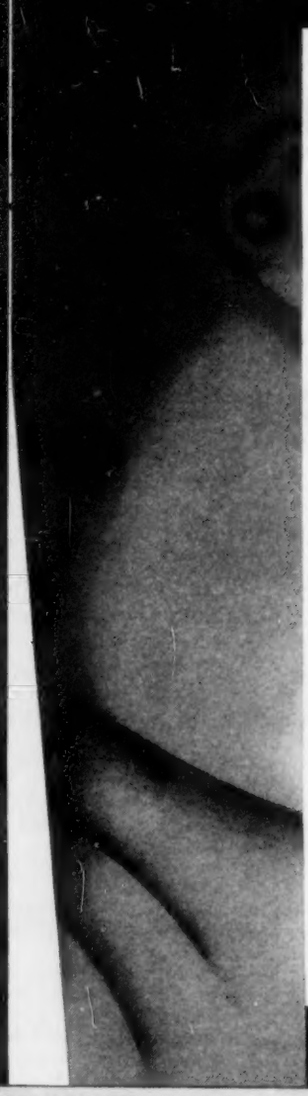

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In Business for Your Safety

Field Welded Pressure and Variable Volume Storage Tanks*

By Fred L. Plummer†

THE safe and economical storage of large volumes of volatile liquids and gases has become one of the most important problems of many of today's great industries. In the Petroleum Industry the use of the more volatile products such as natural gasolines, aviation gasolines, toluene, butane, butene, propane and propalene has been widely expanded during the current war emergency. The development of the many new synthetic rubbers has necessitated the production and storage of great quantities of butadiene, isobutylene, styrene, acrylonitrile and other important ingredients. The Chemical and Munition Industries must store a wide variety of new products in addition to such basic materials as hydrogen and ammonia. Natural gases must be stored in large volumes at specific locations in order to meet sudden peak demands of industrial and private consumers. Many municipalities have found it advantageous to store and use the waste gases recovered in the disposal of domestic and industrial sewage.

In determining the proper type of container in which to store a given product, it will usually be necessary to consider four major factors. The relative importance of these four factors will depend upon the physical and chemical characteristics of the product to be stored and the purpose of such storage. In specific cases other factors may also influence the selection of the type of container. One must first consider the possibilities of loss of product through fire together with the resulting danger to life and to other properties. The importance of this factor is obvious if, as is often the case, the stored product or a mixture of its vapor with air is explosive or inflammable. The Bureau of Mines has completed extensive investigations to determine "explosive ranges" of various gas mixtures and to develop means of eliminating or mitigating the explosion hazards of combustible gases. Thus it has been established that mixtures of air and gasoline vapor in which the percentage of gasoline vapor may vary from $1/2$ to about 6% are explosive whereas richer mixtures are not explosive. Jones and Kennedy[1] of the Bureau of Mines have reported on the possibilities of preventing butadiene-air explosions by the addition of nitrogen and carbon dioxide. This is typical of the studies reported by this Bureau. The vapors of some products, as for instance acrylonitrile may be highly toxic. In some metropolitan areas it is required that storage facilities for certain volatile products be constructed underground.

The second major factor which must be considered concerns the maintaining of the "quality" of the stored product. The loss of a relatively small quantity of the lightest fraction of a blended gasoline with high octane rating may materially reduce that rating and the resulting market value of the entire remaining volume of the gasoline. The presence of air or water in containers used to store butadiene or isobutylene will result in the formation of peroxides which may act as catalyzers and accelerate undesirable dimerization or polymerization while the material is in storage. The temperature at which these products are stored is of even greater importance since the rate of polymerization of butadiene, for example, increases very rapidly with increase in temperature above 32° F. Light has an appreciable effect on styrene and acrylonitrile. The presence of rust might have an undesirable effect on certain stored products. These effects must be considered in selecting the proper type of container and in determining the necessary operating conditions.

Actual losses of stored products are caused by leaks or by some form of evaporation. By the use of welded construction it is relatively easy to provide liquid and gastight containers, thereby eliminating the loss of products by leaks. However, it is much more difficult to eliminate all evaporation losses because of the necessary changes in volume of air-vapor mixtures, as containers are filled with volatile liquid products or emptied, and also as the temperature of the air-vapor mixture and the stored product may vary. Evaporation losses are usually divided into three types: breathing losses, filling losses and boiling losses. In any large field erected tank of fixed volume, there will normally exist a space above the stored liquid which will be filled with a mixture of air and vapor from the liquid. During the day the temperature at the liquid surface will usually be raised, thereby increasing vaporization and the degree of saturation of the air-vapor mixture. Moreover, the accompanying increase in temperature of this air-vapor mixture will result in its expansion and the loss of a certain volume through the safety relief vent. During the night, temperatures drop, some condensation takes place, the air-vapor mixture contracts and fresh air is sucked into the tank. This daily cycle modified somewhat by weekly and monthly temperature variations, as well as by rapid variations such as those caused by a sudden rainstorm on a hot sunny day, may result in serious losses of the stored product and, also, cause important variations in the quality of the remaining product. The amount of breathing losses for a given product will depend upon the size and shape of the storage tank, the volatility of the product, the volume of the vapor space, the temperature variations in the vapor space and at the surface of the liquid, and the pressure and vacuum settings of the relief vents. Temperature variations inside the tank will, of course, depend not only on the variations in atmospheric temperature at the tank site but, also, on the size and shape of the tank, its color and insulation, if any.

When liquid is removed from a fixed volume tank, air must be allowed to enter the tank, and there will remain a tank full of air-vapor mixture. If the tank is then filled with liquid, this tank full of air-vapor mixture must be vented and lost. This is a filling loss which becomes very serious when volatile products which must

* Presented at the 25th Annual Meeting A. W. S. Cleveland, Oct. 16 to 19, 1944.

† Chief Research Engineer, Hammond Iron Works.

be handled at short intervals are stored in fixed volume tanks. The volume of product lost during one filling and emptying cycle will depend to a considerable extent upon the rates at which these operations take place. If the tank could be emptied very rapidly, there might not be sufficient time for the formation of a saturated air-vapor mixture by vaporization from the liquid surface. However, the usual rates allow ample time for such vaporization. If the filling rate is very high, the incoming liquid may cause considerable turbulence and result in greater losses than would result from the displacement of a tank full of saturated vapor.

If a volatile liquid is stored in containers such that the liquid will boil at atmospheric temperatures and at the maximum safe pressure which the container will withstand, then prohibitive losses will, of course, occur. Pressure vessels capable of withstanding the required pressures must be used in order to economically store such products.

Because of the large number of variable factors, their wide range and the accidental character of their occurrence, it is not possible to accurately predict evaporation losses of these types. However, as the results of many tests and analytical studies, it is possible to estimate the amount of such losses which may be expected under average conditions. Happel and Heath,[2] Ashley,[3] Larson[4] and others have developed formulas, charts and tables suitable for such studies. The average rate of evaporation loss of a petroleum product from the commonly used types of cone-roof tanks equipped with conservation vents may equal about one gallon per year per square foot of liquid surface per pound vapor pressure (absolute) of the product at the mean storage temperature. The corresponding filling loss in a similar tank for a relatively low vapor pressure petroleum product might equal about $^1/_4$ of 1% of the throughput. Thus, if a product, having a vapor pressure of 8 psi. at the average storage temperature, were stored in a 55,000-bbl. cone-roof tank with conservation vents and having a diameter of 102 ft., a yearly breathing loss of approximately 65,000 gal. of the product might be expected. If this same tank were filled and emptied once each month, the corresponding yearly filling loss would probably exceed 70,000 gal. of the product. Assuming the product to have a value of only six cents per gallon, the total loss would exceed $10,000 per year. It is obvious that it would be economical to increase considerably the initial cost of this storage vessel if, by so doing, these high annual losses could be materially decreased.

Cost is the final factor which must be considered. In selecting the most economical type of container for a given service, one must consider not only the initial costs of the various types of vessels suitable for that service but must also consider and evaluate all of the other factors which have been discussed. In addition one must consider operating and maintenance costs, possible savings through the use of insulation or other methods of decreasing temperature variations inside the container, the economic advantages of special methods of preventing corrosion of the container material, and the relative costs and effectiveness of the appliances such as relief valves, gages, etc., necessary for the successful operation of the various types of containers.

Fixed Volume-Atmospheric Pressure Tanks

For many years almost all petroleum products were stored in cone-roof tanks. These tanks, which usually consisted of riveted or bolted steel plates, had flat bottoms laid directly on the surface of the ground, cylindrical shells and cone-shaped roofs with open vents. Sometimes the roofs were constructed of wood with the primary purpose of keeping rain and snow out of the tank but permitting a free circulation of air. The initial cost of such tanks was low; however, both breathing and filling losses, increased by the air currents in the vapor space, were excessive. Fire hazard was severe. Such tanks are not now considered suitable for the storage of volatile liquids. Modern cone-roof tanks usually consist of welded steel plates. The rectangular and sketch plates of the flat bottom are usually connected by lap joints. The vertical and girth joints in the cylindrical shell may be "lap" for small tanks but are butt joints in all large tanks. The shell plates are welded directly to the bottom plates and to a roof angle at the top. The roof plates are usually connected with lap joints. The tanks are constructed so as to be liquid- and gastight and are equipped with relief valves designed to open at pressures slightly above and below atmospheric pressure, thus insuring that no excess pressure or partial vacuum can be built up inside the tank. Such tanks are economical and suitable for the storage of heavy crude oils, kerosene, some fuel oils, and other products of low volatility, for which breathing and filling losses will be relatively low. The fire hazard is much less than for tanks with open vents. It is possible at small additional cost to construct these tanks so that they can safely operate at excess internal pressures up to about $^1/_4$ psi. Vessels of this type are usually designed in accordance with Specification No. 12-C of the American Petroleum Institute, which provides for a basic factor of safety of 2.6 (actually about three since design is based on storage of water whereas the actual products stored usually weigh less than water) for steel plates and permits a weld joint efficiency of 85% for butt joints. The factor of safety for structural members is also approximately three.

Variable Volume Tanks

Breathing and filling losses from volatile liquids which do not boil under usual atmospheric conditions at the storage site, can be very much reduced by the use of variable volume tanks, of which there are two major types. Tanks of the first type are constructed so that the volume of the vapor space above the stored liquid can vary. Such tanks are used to eliminate or materially reduce all breathing losses. They are most effective when used for the storage of volatile products which remain in the tanks for relatively long periods, so that filling losses are of less importance. Breathing losses are eliminated from properly proportioned tanks since the volume of the vapor space is increased as the volume of the air-vapor mixture expands with increase in temperature, thus preventing a material increase in pressure and the necessity of venting a part of the air-vapor mixture. As temperatures drop, the volume of the vapor space is decreased, preventing the forming of a partial vacuum and the necessity of sucking fresh air into the tank. Tanks of this type decrease filling losses somewhat but are not as economical as those of the second type for storing products which must be moved frequently and for which the potential filling losses will be very great. Several different designs for tanks of this first type have been developed and made available commercially by the comparatively small group of companies which fabricate and erect large storage vessels. One of the early designs provided a flexible steel diaphragm, referred to as a "breather roof," covering the top of a storage tank. The volume of the vapor space could vary within rather narrow limits as this diaphragm flexed upward or downward. A modification of this

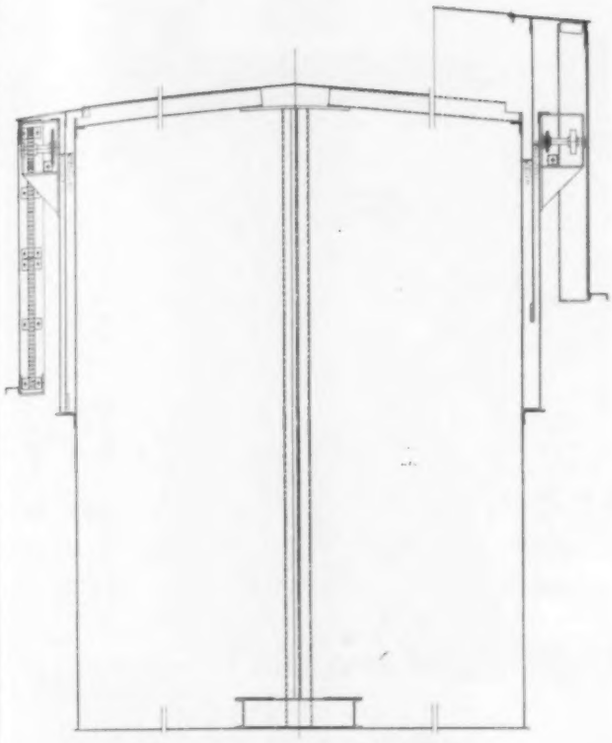

Fig. 1—Hammond Vaporlift Roof

design, called a "balloon roof," operates in a similar manner; however, the flexible roof diaphragm is carried beyond the shell of the tank so as to increase the change in volume of the vapor space which occurs as the diaphragm flexes up or down. In each case the roof diaphragm is supported in the down position by internal column and beam structures.

Vaporlift Roofs

A more recent design, known as a "vaporlift roof," is illustrated in Figs. 1 and 2. The roof normally rests on the usual roof supports as in a fixed volume cone-roof tank. When the volume of vapor in the tank tends to increase, due to a rise in temperature or other cause, the roof rises vertically, increasing the vapor space. A liquid seal, selected to meet the lowest operating temperatures, prevents the loss of vapor at the junction of roof and shell. Simple and rugged stabilizing means consisting of an endless chain or cable extending around the tank and connected mechanically to vertical columns attached to the roof at regular intervals, keep the roof level at all times regardless of lateral wind or unbalanced snow or other loads. This stabilizing equipment is located outside the tank with all parts accessible for inspection and adjustment at any time. However, this equipment, as well as the liquid seal, is fully protected from the weather by the wind apron. A heavy circular girder holds the shape of the roof constant as it rises or drops under working conditions. A gas pressure of from 1½ to 3 oz. per square inch, depending upon the size of tank and the height of lift required to eliminate breathing losses for the product stored, is normally required to raise the roof. Suitable pressure-vacuum relief valves are used to prevent accidental excess pressures or vacuums. The liquid seal and dip ring are designed to relieve excess pressures in case the relief valve fails to function. It is frequently economical to work one tank with a vaporlift roof together with other tanks having fixed roofs by interconnecting the vapor spaces of all of the tanks. In this manner breathing losses from all the tanks can be eliminated or very much reduced. The working pressure required to lift the roof can be lowered by the use of counterweights if desirable. Occasionally conditions may warrant the use of a variable volume tank to be used exclusively for the storage of air-vapor mixtures. In such cases the lift-type gasholder with either wet or dry seal may be used. A piston type gasholder has recently been announced in which a cone-shaped steel piston is counterbalanced and supported on a central cylindrical column. A flexible curtain is used to seal the space between the outside rim of the piston and the shell of the tank, and between the inside rim of the piston and the central column. Vapor is stored in the dry space between the top of the piston and the roof of the tank.

Floating Roofs

Variable volume tanks of the second type are constructed so as to largely eliminate the vapor space which normally exists between the surface of the stored liquid and the roof of the tank. This is done by the use of tank roofs which float on the surface of the liquid in the tank and rise and fall as liquid is pumped into or out of the tank. The use of this type of tank will result in the elimination of almost all filling losses. They are therefore most economical when used for working tanks which are filled and emptied at frequent intervals. Filling losses are eliminated since a tank full of air-vapor mixture is not created as the tank is emptied and then vented as the tank is filled. Breathing losses are also largely eliminated since there is but little space in which air vapor mixtures can form. However, it is difficult to create a perfect seal between the floating roof and the tank shell. Therefore, standing losses from floating roof tanks will be somewhat greater than from variable volume tanks of the first type. Moreover the collection of rain and snow on the floating roof creates problems which may be even more difficult of solution in areas where very low temperatures may be expected. Early designs for floating roofs usually consisted of a flat steel deck with a vertical rim at the edge forming a pan. Modern designs consist of a steel deck supported on pontoons since this form of construction results in much greater buoyancy and practically eliminates the possibility of the roof sinking. In order to provide for irregularities in the shape of the tank shell as the roof moves up and down, a space must be left between the roof and the shell. This space is closed by means of special seals of which a large number have been developed and patented. In Fig. 3 there is illustrated one such design suitable for use on welded tanks. The sliding shoes, *a*, consist of an extruded corrosion-resistant nonsparking aluminum section formed so as to contact the tank shell along two horizontal sections. Thus if the shoe is passing over some minor obstacle at its upper line of

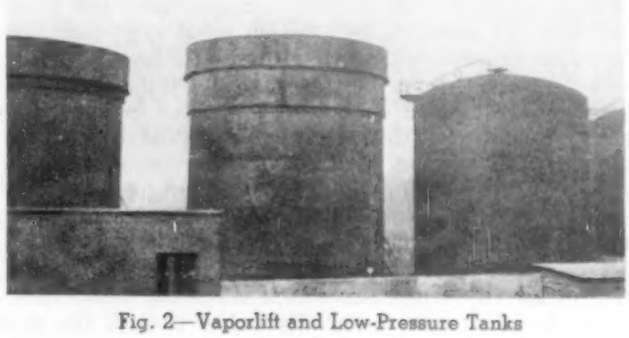

Fig. 2—Vaporlift and Low-Pressure Tanks

contact and is held a small distance away from the tank shell, the lower line of contact remains tight against the tank shell. The sliding shoes are connected through hinges to the cone-shaped steel apron plates, *b*, which are in turn connected through hinges to the steel deck, *c*. The segmental apron plates and shoes can swing in or out in order to provide for variations in the width of the space between the deck and the shell. Leaf springs, *d*, in combination with the rotating moment created by the weight of the shoe and apron, keep the horizontal pressure between the sliding shoes and the tank shell substantially constant. The narrow gaps at the top, bottom and sides of the steel aprons are sealed with narrow strips of flexible materials, *e*, consisting of light gauge non-corrosive metals or heavy fabrics coated with Koroseal, Neoprene or equivalent synthetics which are resistant to the action of petroleum vapors and atmospheric conditions. A secondary wiper seal, *f*, consisting of a loop of similar flexible materials, is provided to exclude air currents and to improve the seal. Auxiliary roller guides attached to the floating

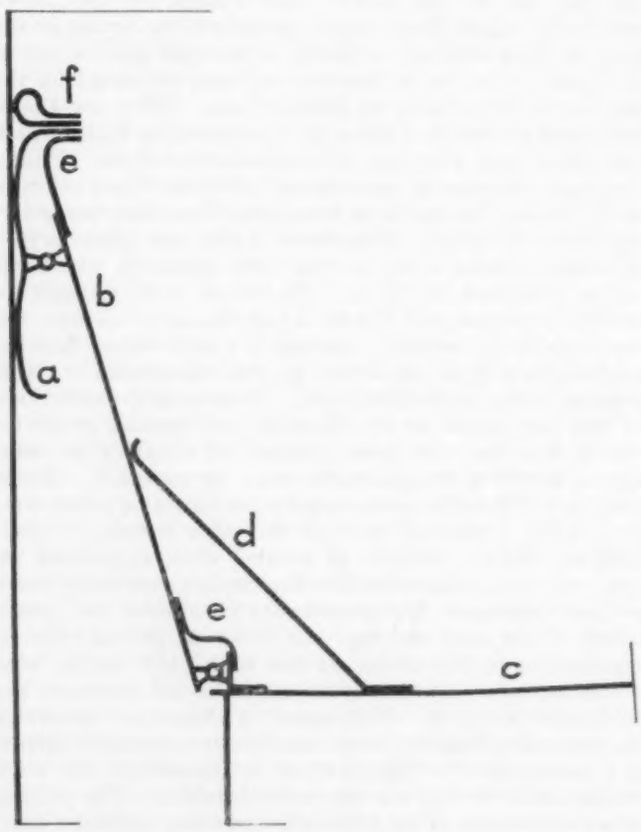

Fig. 3

roof and held against the tank shell by compression springs are provided to keep the roof centered in the tank and to prevent its rotation as it rises and falls. Access to the floating roof is provided through a rolling ladder attached to a platform at the top of the tank shell. Water which collects on the roof is drained to low spots and then through a siphon drain directly into the product stored in the tank or, if this is undesirable, it is collected in sumps and then carried away through a flexible conduit or pipes with hinged joints. The steel deck is normally supported a short distance above the surface of the stored liquid thus providing an insulating layer of air-vapor mixture which keeps the temperature of the liquid surface materially below that of the deck

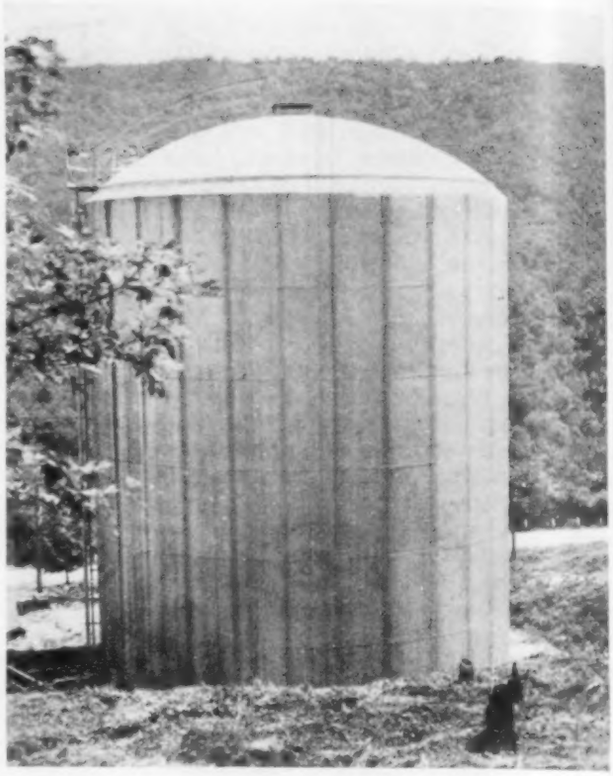

Fig. 4—Low-Pressure Tank

plates when the sun is shining directly on the roof. A rim plate, extending downward and located along the outer line of the pontoons which may be segmental, retains any vapor which is formed in this space until it is again condensed to liquid form. Thus any breathing losses which do occur must come from the very small vapor space which exists below the seal apron and outside the outer line of the pontoons. Floating roof tanks probably are less subject to the danger of fire or explosion than any other type of container. This is due to the fact that air and oxygen are excluded and there is no space in the tank where a large volume of an explosive gas mixture can form. Internal corrosion of the roof and pontoon plates is also minimized because of the lack of oxygen which in cone-roof tanks is continually replenished by the necessary sucking in of fresh air.

Variable volume tanks will be found to be most economical for the storage of motor gasoline, aviation fuels, light crude oils and similar petroleum products which do not boil under normal atmospheric conditions. If it is anticipated that the average storage period will exceed about 60 days, tanks of the first type will usually be found to be most economical. For shorter storage periods and especially in warm climates, floating roof tanks are best. Since all variable volume tanks operate at or very near atmospheric pressure, they are designed in accordance with the same specifications as those used for cone-roof tanks and have approximately the same basic factor of safety of three. Modern floating roof tanks are of welded construction with butt-welded shells. In general, the welding problems encountered in the erection of cone-roof and variable volume tanks have to do with the control of distortions and the production of sound welds under unfavorable climatic conditions. It is, of course, not possible to position welds in field erected structures, and therefore welders must be able to weld vertical, horizontal and overhead joints, as well as those made in the down position.

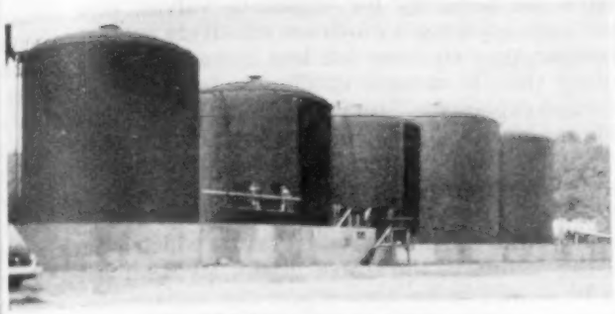

Fig. 5—Low-Pressure Tanks

Pressure Tanks

Volatile liquids which boil under normal atmospheric conditions should be stored in pressure vessels. Many petroleum products, such as natural gasolines, can be economically stored in large containers designed to operate at low pressures of from 2 to 5 psi. Breathing losses of products stored in such containers will be almost entirely eliminated since no venting will be necessary if the tank has adequate strength to withstand the variations in vapor pressure which occur under different temperature conditions. Filling losses will be reduced but not eliminated. The amount of filling losses will depend largely upon the manner in which the tank is worked, that is, whether it is completely filled or emptied in a single continuous operation, or is alternately partially filled and emptied. Corrosion will be less than for fixed volume atmospheric tanks since less fresh air is allowed to enter the tank. For the same reason the richness of the mixture of air and vapor will always be much above the range where explosion and fire may occur. Operation of such tanks is not affected by wind, rain, snow and ice, or other climatic conditions since the tank has no mechanical or moving parts. Maintenance costs are relatively low since only the relief valves need regular inspection. The writer will refer to those tanks which operate at gage pressures of 15 lb. per square inch or less as low pressure tanks.

Low Pressure Tanks

One of the simplest and most economical types of low-pressure tanks is shown in Fig. 4. This is a picture of a 10,000-bbl. tank used for the storage of natural gasoline. It is designed to operate at a gage working pressure of 7½ psi. Comparative records of losses of the same product stored in this tank and in other containers of conventional types operating at much lower pressures, indicate that savings during three months of summer storage more than paid for the additional cost of this container over one of the cone-roof type having the same storage capacity. As indicated in Fig. 4, the roof is dome shaped. It has no internal supports or bracing. The exterior ring angle, which can be seen in the picture, together with an interior angle at the top of the shell and adjacent parts of the shell and roof plates, form a ring girder which prevents the tension forces in the roof plates from pulling the tops of the shell plates inward. The tank shell is cylindrical and its bottom is flat. Diagonal ties are provided to balance the upward force in the shell and the downward pressure on the tank bottom which may exist when the vapor pressure in the tank exceeds atmospheric pressure. Tanks of this type can be constructed with storage capacities up to 55,000 bbl. for working pressures of 2½ psi. and with somewhat smaller capacities for higher working pressures. In larger sizes the dome roof is stiffened with reinforcing structural members. Figures 5 and 6 show views of several low-pressure tanks designed for working pressures of 2½ psi.

Special shape low-pressure tanks such as "spheroids," "ellipsoids," "torospheres" and cylindrical tanks with dished roofs and bottoms have been widely used. The use of pressure tank shells in which the plates are curved with respect to both major axes at any point will in general result in a saving of material since stresses can be developed parallel to both axes which in an ideal case might equal the full allowable working stress for the plate material. In the shell of a cylindrical vessel with closed ends, the unit stress in the longitudinal direction will equal only one-half that in the circumferential direction for uniform internal pressure. Moreover, the forces created at points of discontinuity as at the junction of roof and shell, and bottom and shell can be avoided. However, the saving in material may be more than offset by other factors. The dishing of steel plates to varying double curvatures is a relatively slow and expensive procedure requiring severe cold working of the plate material. Cost of assembly in the field, fit-up and welding may be much higher for such containers. Under normal operating conditions, as liquid level and gas pressure vary, unit stresses will fluctuate widely and the shape of the container may change appreciably. This may affect operating conditions such as the accurate gaging of the tank contents. The use of such containers is, however, economical for very large low-pressure storage tanks.

There is no generally recognized code or specification covering the design of low-pressure storage vessels. The rules for Unfired Pressure Vessels of the A.S.M.E.

Fig. 6—Low-Pressure Tanks

apply to vessels having interior or exterior pressures in excess of 15 psi. For this reason design procedure is not always based on the same allowable working stresses and load conditions. Those who purchase such tanks should therefore specify the basic factor of safety which they consider desirable. It would seem logical for this type of storage vessel to provide a basic factor of safety of from $3^1/_2$ to 4 based on actual working pressure and weight of product to be stored.

Spheres

Products which are gases at normal atmospheric temperatures such as butadiene, butane, isobutylene, hydrogen, ammonia, sewage gas and many other petroleum and chemical products are usually stored most economically in pressure vessels designed for working pressures of from 25 to 100 psi. or more. If large quantities of the product are to be stored, field erected spheres are normally used. If the product remains a gas under all storage conditions, then the sphere is usually supported on light steel members attached to the sphere near its bottom. Such members are designed to carry the weight of the sphere itself together with the small additional weight of the stored gas and to resist any other external forces such as those caused by the wind. If the tank may be filled with a liquid under certain storage conditions, then heavy vertical columns are usually connected to the sphere at its equator so that the upper half of the sphere may act like a hemispherical dome roof and the lower half of the sphere may be considered a hemispherical suspended bottom. The sides of the sphere must act as curved beams to transfer the vertical loads to the columns. Usually from six to twelve columns are provided depending upon the size of the sphere. Capacities of spheres commonly used vary from about 2000 to 12,000 bbl. A sphere is the most economical form of vessel for withstanding uniform internal pressures since the shell plates are stressed uniformly in all directions. Moreover, the ratio of surface area to volume is less for a sphere than for any other form of container. The use of a single large spherical tank rather than a number of smaller shop-fabricated cylindrical tanks not only reduces materially the tank material but also eliminates the necessity for duplicate valves, pipe fittings and tank appliances which are relatively expensive items. Temperature changes are less extreme in a large container than in several smaller containers of equivalent storage capacity. Storage of volatile products in properly designed spheres will prevent breathing and boiling losses and will materially reduce filling losses. The proper working pressure to be used for the storage of a given product will depend upon the volatility of the product and the highest temperature which is anticipated at the surface of the stored liquid. Thus if isobutane is to be stored in an area where the surface temperature of the liquid may reach, say, 110° F., the storage sphere should be designed for a working pressure of at least 65 psi. since the absolute vapor pressure of isobutane at this temperature is about 79 psi., equivalent to a gage pressure of about 64 psi.

In certain cases it may be economical to store products in insulated containers and at low temperatures. This is especially true for products such as butadiene and isobutylene in which undesirable chemical changes may take place if they are stored at atmospheric temperatures. It has been recommended that these products "be stored at a working temperature of 32° F. with a corresponding pressure of about 3 psi." in insulated low-pressure containers. The East Ohio Gas Co.[5] at Cleveland has found it economical to liquefy natural gas and store it at a temperature of about −257° F. and a gage pressure of only 3 psi. in tanks with double walls separated by about 36 in. of insulation. The storage tanks used in the first installation at this site were double spheres; however, a vessel of the low-pressure type was installed at a later date. This container consists of two vertical cylinders. The inner cylinder has a diameter of 70 ft. and a height of 43 ft. The outer cylinder is separated from the inner cylinder by a space 3 ft. thick, packed with rock wool insulation. Mr. Robinson gives the relative costs of storage in medium pressure containers (5 to 25 psi.), low-pressure gas holders, and as liquefied gas as approximately 20, 8 and less than one cent per cu. ft., respectively. These costs apply to a specific situation and might not hold for dissimilar conditions.*

Spheres, and other medium and high-pressure storage

* Note: This installation was destroyed by fire on Oct. 20, 1944.

Fig. 7—Spheres for Pressure Storage

vessels, are usually designed and constructed in accordance with either the A.P.I.-A.S.M.E. Code for Unfired Pressure Vessels or the corresponding A.S.M.E. Code. Those constructed in accordance with the A.P.I.-A.S.M.E. Code have a basic factor of safety of four. The joint efficiency specified for various types of welded joints (80% for double-welded butt joints, for instance) is multiplied by "construction factors" covering the grade of steel; and radiographing and stress relieving if performed. The joint efficiency is increased 6% for stress-relieved vessels and an additional 12% if the joints have been examined by radiograph and the defects repaired. The joint efficiency is decreased 3% if flange grade is used rather than firebox grade. Thus a joint efficiency of 95% would be permitted for a double-welded butt joint in a vessel constructed in the shop of firebox grade steel, say, A.S.T.M. A-70, which had been stress relieved and radiographed, whereas a joint efficiency of only 78% would be permitted in a field erected vessel constructed of flange grade steel, A.S.T.M. A-70, which had been neither stress relieved or radiographed.

Prior to the current war emergency, pressure vessels constructed in accordance with the A.S.M.E. Code had a basic factor of safety of five. A joint efficiency of 80% was permitted for vessels constructed in accordance with paragraph U-69 of the Code. Early during the war the code was, in effect, modified by the issuing of Case 979 which permitted the construction of pressure vessels including large spheres, having a basic factor of safety of four and a design joint efficiency of 85%. This change brought the two code requirements into substantial agreement. A great many spheres have been constructed during the past few years in connection with the building of our great industrial war production facilities. A group of such spheres is shown in Fig. 7. Another sphere is shown in Fig. 8 being moved. It is one of two identical spheres completed and tested at a new munitions plant. Because of enlargement of the plant it became necessary to move the spheres. After moving they were retested successfully. These spheres, which are 40 ft. in diameter, were designed for the storage of anhydrous ammonia at a working pressure of 75 psi. In order to hold the gas pressure at or below this value, the spheres are covered with insulation and a temperature of about 40° F. is maintained in the stored product. The shell plates are approximately $^{7}/_{8}$ in. thick and are, of course, butt welded at all joints. This welding was successfully completed in the field under adverse weather conditions during the winter months.

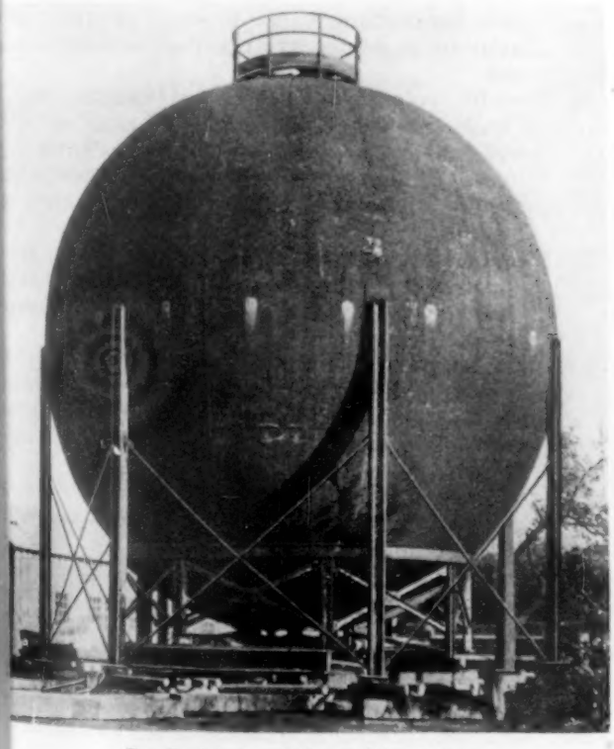

Fig. 8—Moving Spherical Container

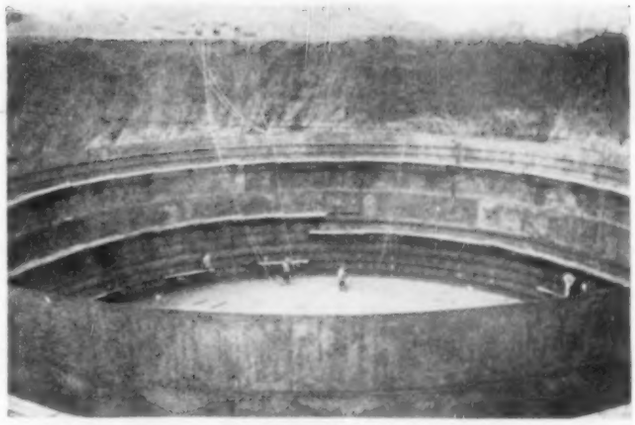

Fig. 9—Underground Tank Shell and Bottom

The design and construction of large spherical pressure vessels involve the solution of many difficult problems. This is especially true if the vessel is to operate at low temperatures which may result in less ductility and lower shock resistance of the steel plate material as well as the weld metal. Current codes permit the use of steels which may not be suitable for low-temperature service. The quantitative effects of cold working during fabrication in rendering steels subject to strain aging are not well understood. It can be demonstrated that locked-up stresses in a simple unstress-relieved structure such as a column built up of several pieces welded together may equal the yield point of the steel. Yet the column when tested to failure will have a strength substantially the same as that of an equivalent rolled section or of a similar welded section which has been stress relieved. We are not sure that the same happy result may be obtained in more complicated structures. The A.P.I.-A.S.M.E. Code now recognizes mechanical "peening" as a proper method of relieving stresses in field erected vessels. Biaxial stresses exist in the shells of all pressure vessels. In spheres these stresses are of approximately equal intensity. We are not sure whether this condition is of great significance or not. The same condition exists at some points in the heads of almost all pressure vessels.

Brown and Smith[6] have described the service failure of a sphere containing hydrogen gas at the design working pressure of 50 psi. This is believed to be the first sphere out of perhaps five hundred which had been constructed at that time to fail structurally while in service. The failure which occurred with explosive violence is believed to have originated in the sheared inside edge of a 20-in. diameter manhole neck where plate shears had left a torn surface. Brown and Smith suggest as possible causes of the failure: (1) a higher than average stress level in the manhole neck, (2) triaxial residual stresses of yield-point values due to shrinkage of weld metal, (3) increased brittleness of the steel plate due to low temperatures at the time of the failure, and (4) the probable occurrence of some type of shock.

The A.S.M.E. Code has recently been modified by the revision of Case 979 and its reissue, permitting the construction of pressure vessels, except spheres, having a basic factor of safety of four and a design joint efficiency

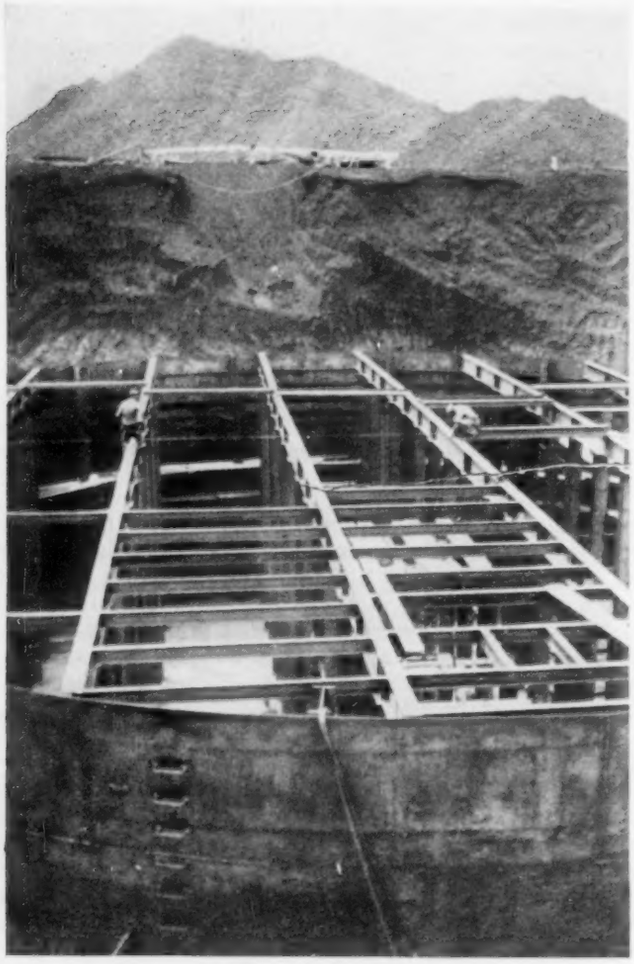

Fig. 10—Underground Tank Roof Supports

of 80%, reduced from 85%. Spheres must now be constructed under this code with a basic factor of safety of five and a design joint efficiency of 80%. It seems probable that this inconsistency may be eliminated when the code committee has had time to formulate more complete rules covering the construction of spheres.

Underground Tanks

In certain metropolitan areas, city ordinances require that storage facilities for products which might create fire or explosion hazards be constructed under ground as a safety measure. During the past few years many large storage tanks have been constructed underground as a means of concealment and to make more difficult their destruction by enemy forces. Underground storage has other advantages. Such tanks have adequate strength to resist low pressures and so have all the advantages of low-pressure tanks. The surrounding earth provides heavy insulation so that temperature variations are small and temperature is held relatively low. Thus breathing and boiling losses are usually eliminated and filling losses may be very much reduced. The disadvantage of such storage lies in the relatively high cost of such storage tanks. Those built in metropolitan areas where land values may be very high are often large rectangular or irregularly shaped prisms occupying the entire available area. These tanks are braced internally to withstand the external forces as well as the excessive internal pressures which are specified in some city codes. Those built in areas where land values are low are usually constructed with cylindrical shells and flat roofs and bottoms.

The construction of one such tank is shown in Figs. 9 and 10. The tank is 100 ft. in diameter and 30 ft. high. The bottom of the steel tank which rests on a concrete slab is about 50 ft. below the ground surface. The tank shell is stiffened by ring stiffeners and by vertical stiffeners extending from the tank bottom to the tank roof. The roof is supported by a series of heavy girders and columns. The entire structure was assembled by welding in the field. Butt joints were used for both structural shapes and plates. After this steel tank was completed, it was surrounded by a concrete shell and covered by a heavy concrete slab designed to prevent destruction of the tank by bombing. Many steel tanks of similar construction expect for lighter roof supports have been constructed with a soil cover only a few feet thick and without a protective shell of concrete or a heavy concrete roof slab.

Summary

In selecting the proper type of large field welded container in which to store a given product, one must consider four major factors:

1. Safety from fire or explosion.
2. Maintaining the quality of the product.
3. Preventing loss of the product—breathing, filling and boiling losses.
4. Cost of initial installation, maintenance and operation.

The following types of containers have been found most satisfactory for the products usually stored in large quantities under normal operating conditions:

1. Fixed volume, atmospheric pressure tanks with conservation vents for low vapor pressure products such as heavy crude oils, kerosene and some fuel oils.
2. Variable volume tanks, operating at pressures only slightly above atmospheric pressure, suitable for medium vapor pressure products such as motor gasolines, aviation fuels and light crude oils.

2*a*. Variable volume tanks such as "breather roof," "balloon roof," "vaporlift roof" and "dry and wet seal gasholders" which prevent breathing losses and are usually most economical when the product is held in storage for 60 days or more.

2*b*. Variable volume tanks of the "floating roof" type which prevent filling losses and are usually most economical when the product is held in storage for only short periods.

3. Fixed volume, pressure storage tanks suitable for high vapor pressure liquid products and gases such as natural gasolines, aviation fuels, liquefied petroleum gases and anhydrous ammonia.

3*a*. Low pressure tanks with braced flat bottoms and dome roofs, "spheroids," "ellipsoids" and other special shape tanks suitable for working pressure up to about 15 psi.

3*b*. Medium pressure tanks, usually spheres, suitable for working pressures from about 20 psi. up to 100 psi. or more.

4. Underground storage tanks having a high initial cost which are generally used because of restrictive building ordinances or for concealment and protection from enemy action.

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Welding of Locomotives for Main Line Operation*

By O. K. Kjolseth†

FOR nearly a century the railroad industry built steam locomotives by the casting, bolt and rivet method, and naturally it was not inclined to discard, overnight, a proven method of manufacture in favor of the new development, electric welding.

Through later years, however, electric welding had proved itself superior to other methods of construction in many industries, as well as here and there on railroad applications. Now it is rapidly earning a good acceptance in the railroad industry for one of the most important jobs of all—rolling stock.

For years the General Electric Co. has been fabricating by welding, complete electric locomotives for switching and industrial use. It found long ago that it could get a lighter, stronger construction, do the work faster, and lower the cost as well. Practically all of the mechanical portion on G-E switchers are welded.

Fabrication by welding, of large locomotive units such as truck frames, cab and underframe structures, gives many manufacturing advantages which are of considerable importance.

The elimination of pattern work and storage facilities are large items in cost reduction. Unless weight limitations require special material of higher tensile strength, parts can be laid out and torch cut from standard stock material. Such parts are relatively small, and can be stored where the space would not accommodate large finished units such as frame castings. As needed, they are brought to various sections of the factory and welded into subassemblies which are later brought to the assembly floor for assembly into complete welded units. The uniform dimensions of the structural material eliminates much machine work, and in most cases, any machining that is required can be performed on individual parts or subassemblies. Thus, special machines to handle large assembly units are not needed.

The General Electric Co. recently completed an order of main-line electric locomotives for the Sorocabana Railway in Brazil (Fig. 1). These locomotives are also of all-welded construction designed to handle passenger, freight and mixed trains over a mountainous terrain between São Paulo and Santo Antonio in the state of São Paulo.

General Description of Sorocabana Locomotive

Classification.....
.....1-C + C-1-238/286-6GE734-3000 volts
Length, over-all, inside of coupler knuckles.....
.....61 ft. 0 in.

Fig. 1—Three-quarter View of Sorocabana Locomotive

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16-19, 1944.

† Locomotive Engineering Division, General Electric Co.

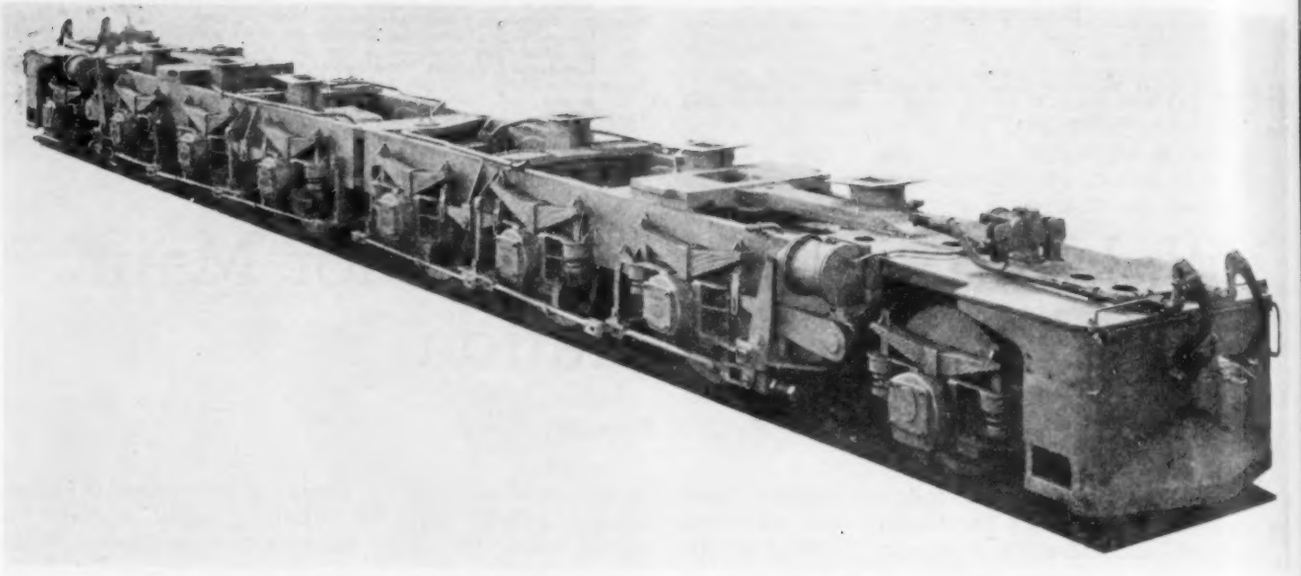


Fig. 2—Assembly of Driving and Guiding Trucks Complete

Width, over-all	9 ft. 7 1/8 in.
Track gage	1 meter
Diameter driving wheels	44 in.
Diameter guiding wheels	33 in.
Rigid wheel base	13 ft. 0 in.
Total wheel base	50 ft. 0 in.
Total weight in running order	286,000 lb.
Weight on drivers	238,000 lb.
Number of motors	6
Continuous rating (hp.)	1910
Continuous tractive effort (lb.)	24,475
Speed, continuous rating (mph.)	29.3
Maximum safe speed (mph.)	56

Driving Truck

The three-axle driving trucks (Fig. 2) are articulated by a ball joint arranged to permit angular movement in both vertical and horizontal planes. The outer end of the truck extends over the guiding truck, and carries draft gear coupler and pilot.

Side frames are universal mill, rolled open-hearth steel, 3 1/2 in. thick, normalized, with an ultimate tensile strength of 55,000–65,000 psi., maximum carbon content 0.25%. All other parts are made from standard commercial plates and structural shapes of good welding qualities (Fig. 3). After preparation of individual parts, they are welded into subassembly units, consisting of side frame with pedestal brackets, articulation end frame, cross ties, including center plate socket and loading pad supports, frame extension, coupler and draft gear housing, etc.

All required machining such as boring of center plate socket in main cross tie, squaring of cross tie plates and boring for articulation pin bushings in end frame, is performed on individual parts or subassemblies. Subassemblies and parts are then placed in a general assembly fixture (Fig. 4), aligned and trammed to required tolerances and clamped in position for welding. Intersecting

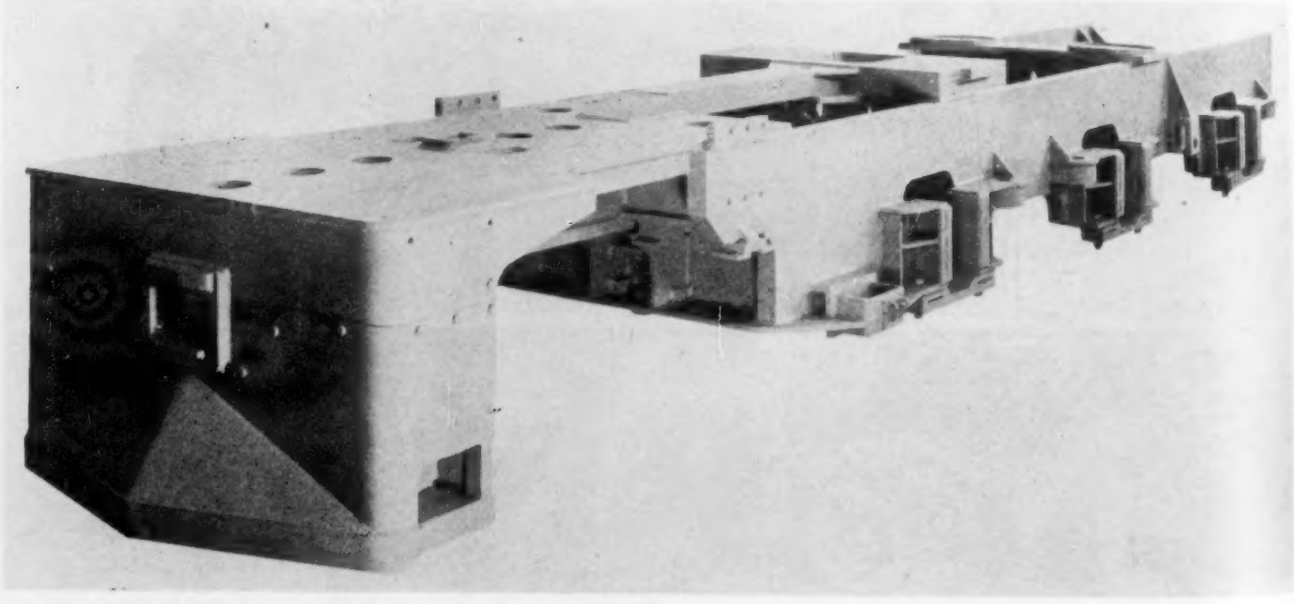


Fig. 3—Driving Truck Frame

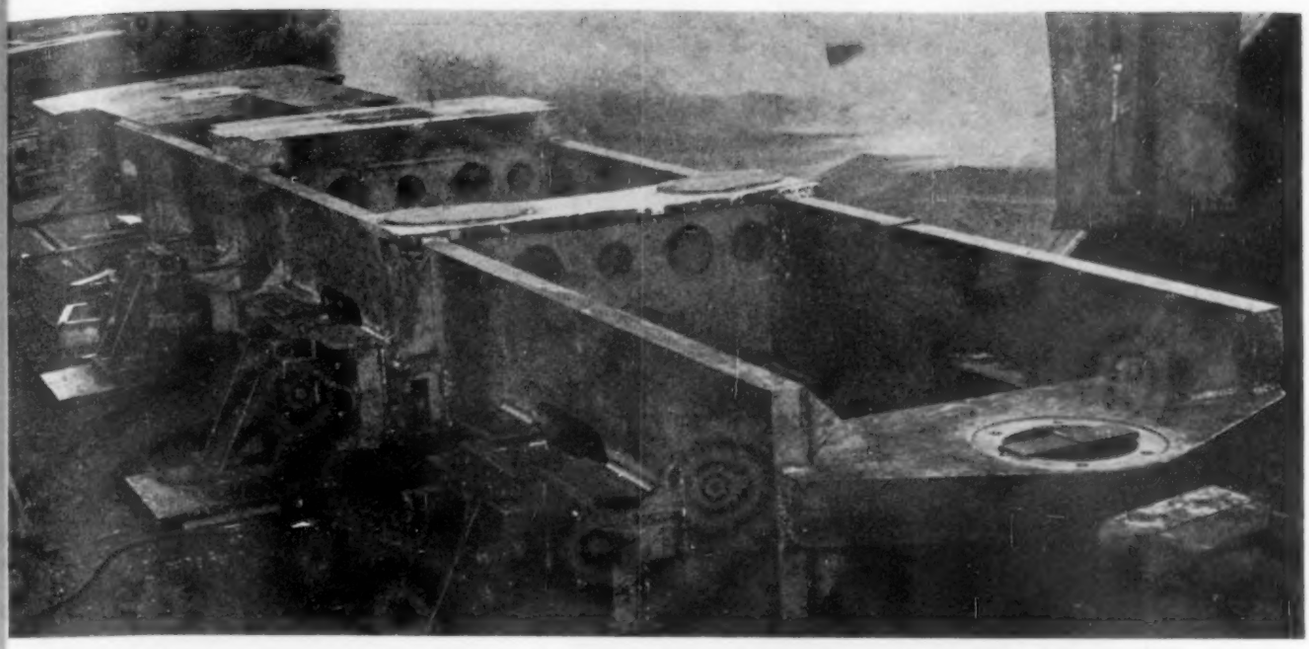


Fig. 4—Driving Truck Frame with Journal Pedestals Set Up in Fixture During Process of Welding

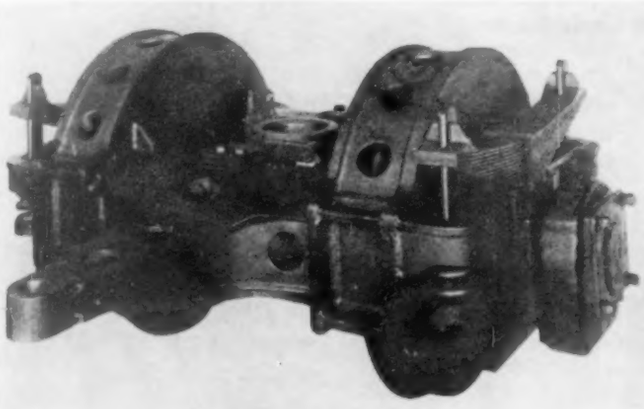


Fig. 5—Guiding Truck

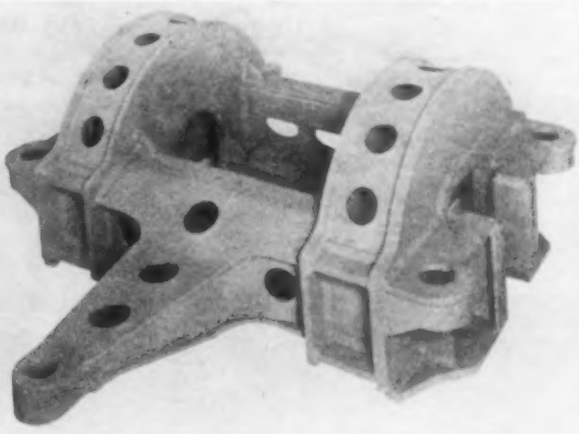


Fig. 6—Guiding Truck Frame

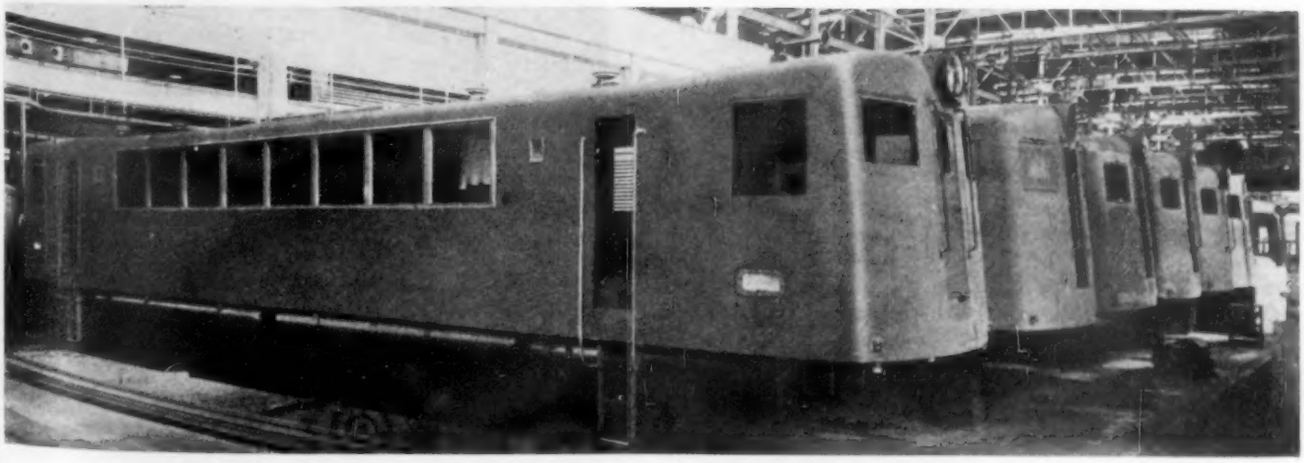


Fig. 7—Cabs Under Construction

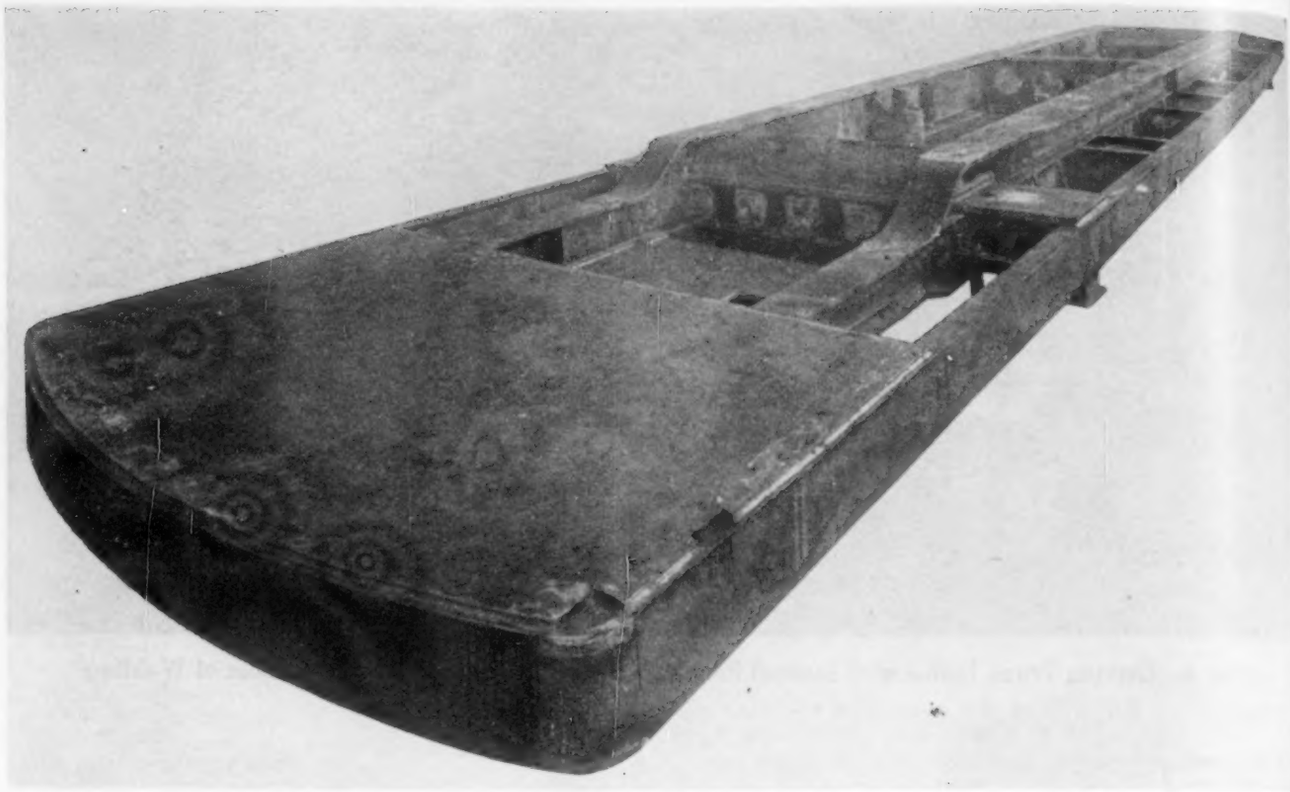


Fig. 8—Cab Underframe

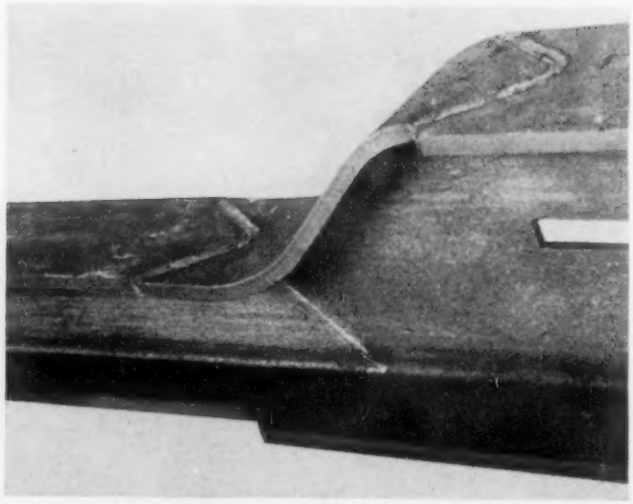


Fig. 9—Sill Beam for Cab Underframe Showing Method of Splicing 18-In. and 8-In. Beams

portions of parts to be welded together such as side frames, cross ties and end frames are preheated to a temperature of approximately 200° C. By experience it was found that by laying heavy welds, such as used in joining cross ties to side frames, a contraction takes place, in and around welds, of sufficient magnitude to draw the side frames together by approximately $^{1}/_{16}$ in., more or less, depending on thickness of material and size of welds used. This contraction, of course, is compensated for by actually machining cross ties longer by the amount of expected contraction. An experienced welder can do much in controlling shrinkage, distortion and misalignment in welded structures by his skill in operation of welding tools and sequence of weld applications.

After the frame is otherwise assembled and welded, pedestal shoes, forming guides for journal boxes, are set to position in a special fixture. Shoes are accurately trammed to position for squareness and distance, laterally

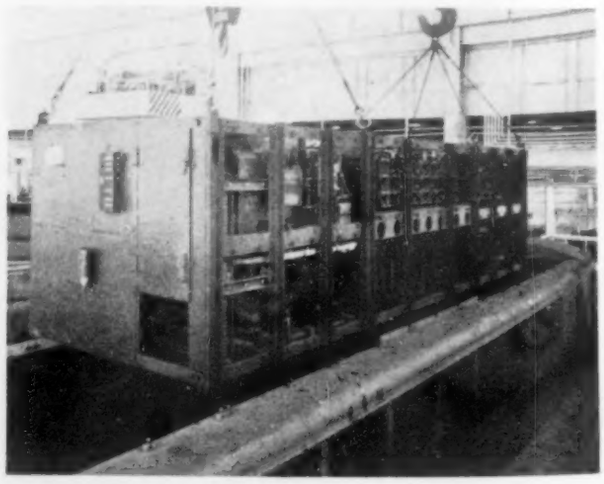


Fig. 10—Apparatus Compartment Unit

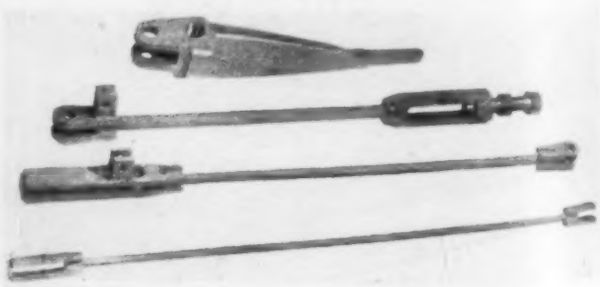


Fig. 11—Miscellaneous Welded Parts for Brake Rigging

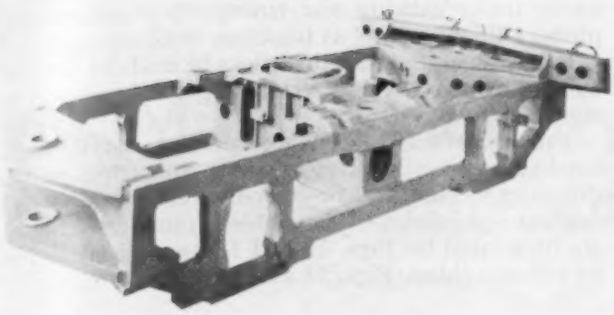


Fig. 12—Truck Frame (Outer)

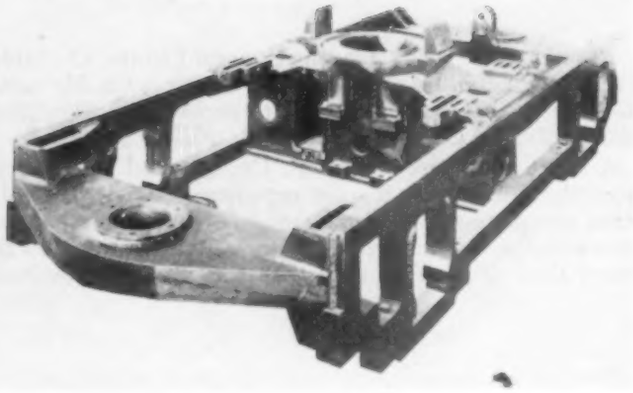


Fig. 13—Truck Frame (Middle)

as well as longitudinally to frame centerline, and are then securely welded to pedestal brackets.

Guiding Truck

The guiding trucks are equipped with outside journals and rolled steel wheels. Semielliptic and coil springs are arranged in series over top of the journal boxes. A laterally movable bolster with graduated gravity restraint is provided to give improved riding qualities (Fig. 5).

The guiding truck frame (Fig. 6) is also completely welded. Side frames are made from steel boiler plate 1½ in. thick with a tensile strength of 55,000–65,000 psi. Other parts of frame are made of commercial steel plates and shapes of good welding qualities. This frame is also set up in a special fixture and then placed on a universal welding table where flat-positioned final welds are laid.

Cab

The cab is of semistreamlined design (Fig. 7), erected on a platform or underframe and is carried on two centerplates located one on each of the two driving trucks. Additional cab supports are provided through four spring-cushioned loading pads slidably supported one on each side of each driving truck. The loading pad springs are calibrated to give desired load distribution on all wheels.

The cab consists mainly of exterior steel sheets 0.180 in. thick, and a 4-in. steel channel frame. Sides are built in subassemblies positioned horizontally in a fixture set up on a steel floor bed. Clamps are used to secure stiffeners or carlines in position while being welded to the sheets.

For the final assembly of cab, the various subassemblies are erected on the underframe and welded in place. All exterior seams are ground smooth, and louvers, doors, windows, hatch covers, etc., are fitted to produce a smooth appearance of the structure as a whole.

Welding lends itself very well to the making of curved sheets for the streamlined portion of cab, as such sheets can be made from small parts curved to desired shape and then joined together by welding into larger units.

The cab underframe (Fig. 8) is constructed of commercial steel shapes, bars and plates throughout. The structure is about 54 ft. long by 9 ft. wide. The center sill, which is the main load-carrying member of the frame, consists of two 18-in. by 12-in. H-beams extending well beyond the bolsters where they are joined with 8-in. H-beams (Fig. 9) extending to ends of frame.

Apparatus Compartment

The apparatus compartment (Fig. 10) is built as a separate unit to facilitate easy installation of electrical apparatus and wiring. After being completely equipped, it is lowered through hatch opening in cab roof and securely welded to underframe and roof structure.

Miscellaneous Welded Parts

Miscellaneous parts (Fig. 11) such as main brake arm, levers, rods and adjusting screws, also spring equalizers and hangers are of all-welded design.

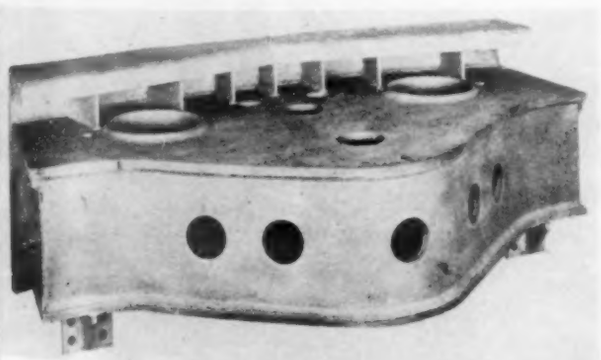


Fig. 14—Outer End Frame, Subassembly

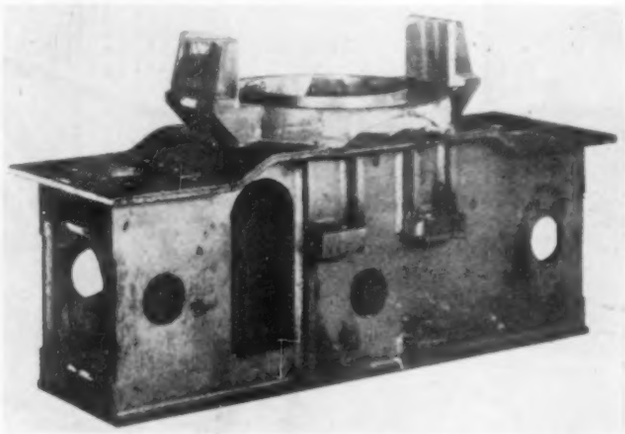


Fig. 15—Center Transom with Center Plate

Spare Locomotive Trucks for Mexican Railways

About twenty years ago, the General Electric Co. built a number of 150-ton electric locomotives for the Mexican Railways. The running gear or trucks were all of the cast-steel bolted construction.

A short time ago, the G. E. Co. received an inquiry from the railways for a spare set of trucks and span bolsters, complete with motors, etc., to be fully interchangeable with the original trucks. Upon investigation, it was found that all patterns used with the original order had been destroyed, and naturally it would be difficult and costly under existing war emergency conditions to reproduce them, as well as to obtain steel castings.

It was suggested that the trucks be made by the welded method using rolled bar steel and plates in place of castings.

The order was placed accordingly, and the welded trucks and span bolsters are now completed, ready for shipment. They will be fully interchangeable with the original equipment. The welded frame assembly units are illustrated by Figs. 12 and 13; end frame and cross tie subassemblies, Figs. 14 and 15.

Ore Drilling Machinery Built with Arc Welding*

By S. Craig Cairns

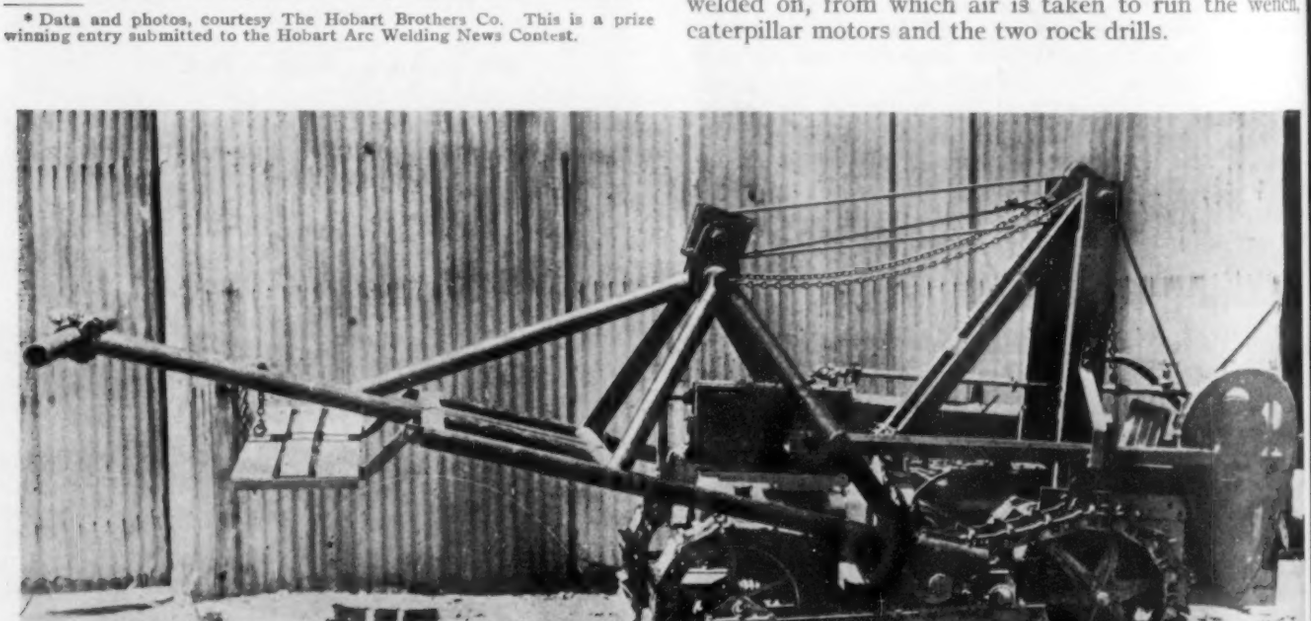
UNIQUE in welded fabrication is this rock and ore driller mounted on a caterpillar tractor and is one of the many specialties that are turned out of the Galena Machine & Electric Co. of Kansas.

Named a "Jumbo," this equipment is driven up to the ore face, the boom is raised to the proper height and a row of holes drilled, then lowered twice more for other rows of holes, then driven to another "setup" and the process repeated. With this machine it is reported that two drillers will do the work of six using the old post or tripod method.

In building the "Jumbo," the internal combustion was removed from the engine and an air head with four slide valves is substituted. The crankshaft was cut at the center bearing and one-half of it given a quarter turn, then welded back together, straightened and refinished. This places the throws of the shaft on 90° around the center.

The cam shaft is driven by sprockets and chain and is timed to admit air to the cylinders at the point where the pistons are at the top of the stroke. The boom is constructed of 3-in. extra strong pipe, one end pivoted to a 3-in. double extra strong pipe by means of $2^1/_4$-in. pins fastened in each end of the 3-in. pipe with set screws. This double extra strong pipe replaces the spring in front of the tractor and supports the engine. At the other end of the boom a 3-in. extra strong pipe 8 ft. long is fastened in the two clamps at the end of the boom and two rock drills are mounted on this plate. The drill operators stand on the platform which is hinged to the boom at the back and supported in front by a chain which is adjustable to keep the platform level. An air-driven wench is built from a Model-A block assembly in the same manner as the engine. The wench drum is mounted above the engine and both are contained in an arc-welded 3-in. angle iron frame. The cable from the wench goes to the derrick and through 3-sheave fall blocks on both the derrick and boom. On one side of the tractor just above the tracks is an air receiver fabricated of 8-in. pipe, 5 ft. long with pipe couplings welded on, from which air is taken to run the wench, caterpillar motors and the two rock drills.

* Data and photos, courtesy The Hobart Brothers Co. This is a prize winning entry submitted to the Hobart Arc Welding News Contest.



How Much Ductility Is Necessary for a Structure or Machine?*

By W. J. Conley†

IT HAS long been customary to specify steels and other metals and alloys by means of values obtained from a tensile test. The importance and reliability of these is based on the fact that they represent results obtained from test samples of metal which have given satisfactory performance in service. However, does this prove that these tensile values are the ones which will properly designate the material for a specific application? Before the engineer or designer can answer this question he should have a thorough understanding of the cross relationships between stresses caused by different kinds of loads and the manner in which variables found in practice affect the ability of the metal to perform as it is supposed to according to the tensile test results. For example, when a definite minimum value for yield point or ductility is specified is this done on a basis of fundamental understanding of the service requirements or is a value settled on because the manufacturer of the metal can produce this material within the limits set? If the latter is the case the value should be designated as arbitrary, and thus others will not be influenced to use a like value with the thought that it was arrived at in a logical manner.

It is more natural for the mind to oversimplify than to expound and seek the real hard truth. Thus it is easier to select some arbitrary figure for a specification than to thoroughly analyze the type of service to see whether or not there are variables in the design which may prevent the metal from performing as anticipated on a basis of the test results. For example, for weld metal the tensile test as specified by the A.W.S.-A.S.T.M. is performed on a test specimen having a cylindrical length of $2^1/_4$ in. and a diameter for this length of 0.500 ± 0.010 in., upon which is marked a 2-in. test length. The ends are prepared to be conveniently gripped, preferably in spherically seated chucks. The load is then applied so that the whole test requires only a few minutes, readings being made of the yield load, maximum load and infrequently of the breaking load. After fracture the final length between gage marks is noted as well as the minimum final diameter. These are the values recorded for a commercial test. It may be that more precise readings of load and elongation are made so as to determine the modulus of elasticity and proportional limit between stress and strain, commonly called elastic limit. Then on a basis of original dimensions, the yield point, tensile or ultimate stress, elongation for 2 in. in per cent (ductility) and reduction of area in per cent are computed. Figure 1 shows a typical engineering stress-strain curve determined as stated above, labeled *oabfde*. Thus it is easily appreciated that the values determined from this test are arbitrary or empirical. The dimensions of the test piece are such that the stress is principally uniaxial, the piece being free to reduce in cross section perpendicular to the direction of load. It is also well known that the section reduces locally after the maximum load is reached, the shape of the curve varying greatly from this point on depending on such variables as the grain size, inclusions, surface conditions, temperature of test, etc. Figure 2 shows engineering curves approximately correct as to shape for low-carbon steels (*A*, *B* and *C*) and for low-alloy steels (*D* and *E*).

It is realized that this discussion is fundamental, but it is included to develop the proper mental picture to attempt to influence the engineer and designer to select or specify values according to the performance actually needed and on a basis of the ability of the material to perform in the structure. The objective is to cause thought in terms of the actual application not in terms of an arbitrary test which should be regarded as a control test only. After careful study and analysis it may be found that the imposed specifications are too strict or too

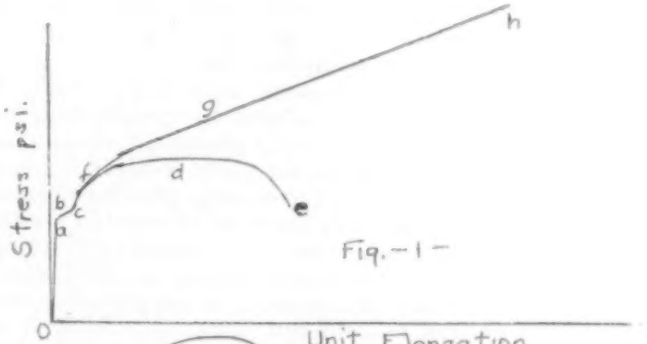


Fig.-1-

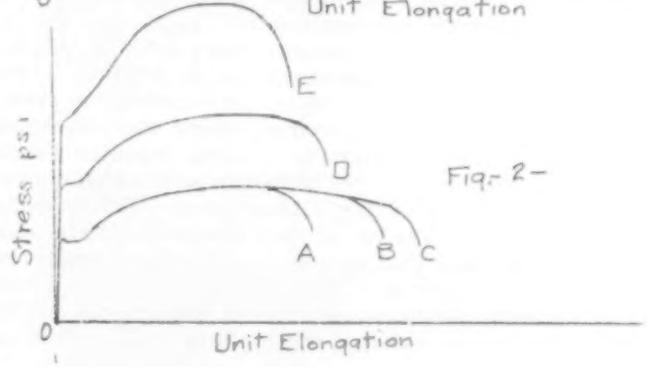


Fig.-2-

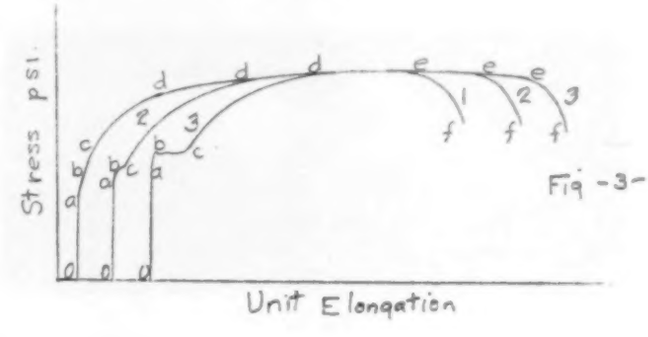


Fig.-3-

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944.

† Consulting Engineer, The Lincoln Electric Co., Cleveland, Ohio.

loose, in any case conclusions should be drawn as accurately as possible.

Returning to the curve *Oabfde* of Fig. 1 it is seen that it can be divided into five parts. *Oa* shows practically straight-line relation between stress and strain or elastic action; *ab* represents mixed elastic and plastic conditions, while *bc* is practically plastic action only; *cfd* shows mixed elastic and plastic relations between stress and strain with more plastic than elastic. The shape of *de* is probably influenced not only by the inherent properties of the material but by variables introduced in the manufacture. Thus it is seen that percentage elongation is made up of elongations represented by the permanent stretch produced from *a* to *e*. The whole may be made of a relatively small amount from *b* to *c* with relatively large amount from *c* to *e*, or the reverse. This is shown in Fig. 3 by curves 1 and 3. However, if a part of a structure were loaded to point *d* it would be practically unfit for further service so that the stretch from *d* cannot be included as a useful criterion of performance. Thus it can be seen that the specification for elongation alone does not tell the whole story unless the shape of the curve is visualized at the same time. In fact, such large values as indicated by the whole curve are of interest only to those planning deep drawing or severe forming operations on the metal. For design purposes for machines and structures, no permanent elongation would be necessary since the working stress is chosen to be well below the proportional limit where no permanent elongation takes place or at least an extremely small amount. In this case why is the ability of the material to permanently elongate or have ductility a factor in its choice or specification? The answer to this question entails an understanding of the loading and the internal structure of the metal and the manner by which it adjusts itself to the stresses set up by the load.

Per cent elongation as measured in the tensile test is of interest and can be used as a basis for specification, for raw material to be shaped cold by plastic deformation as in deep drawing operations, for parts in their finished form which may be expected to undergo plastic deformation in service, for parts not expected to undergo plastic deformation but through abuse or accidental overloading may be subjected to stresses greater than the yield point, for applications where the engineer or designer does not expect the material to yield, but thinks that ductility is necessary to insure that the metal will have other properties, or to allow for adjustment where internal stresses may develop during fabrication as in welding. This thought may have been prompted by experience as previously stated, where the material, which had performed satisfactorily under conditions of shock, repeated stressing, high temperature, etc., showed a large value of percentage elongation during a tensile test. Before using the elongation as a criterion the designer should be sure that it does insure that the metal will perform under the load conditions as expected, otherwise he will be led into a mental state of false security which is dangerous. The danger lies in the fact that the problem is thought of as solved, whereas actually the specification written with the above attitude may be adding greatly to the cost of the structure or machine.

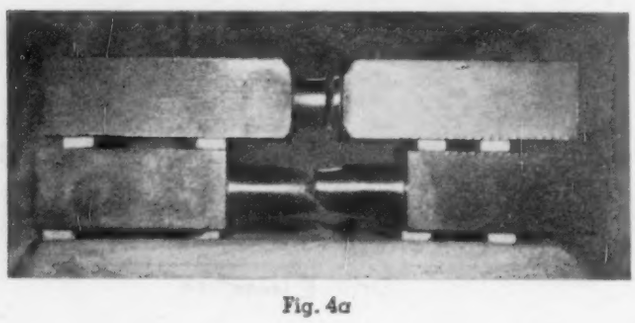


Fig. 4*a*

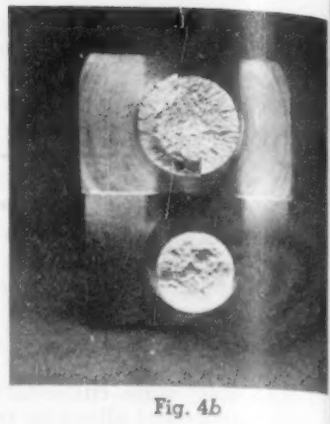


Fig. 4*b*

All metals are known to be crystalline, namely, made up of units, called grains which have an internal geometrical atomic pattern. This pattern produces directions or planes along which shear displacement can take place with greater ease along some than others. It is this shear displacement which allows permanent deformation or plastic flow which is reported as percentage elongation or ductility in the tensile test. It is well known that a tensile stress in a given direction sets up a secondary shear stress along a plane at any angle to this stress which is a maximum at 45° and equal in intensity to one-half of the tensile stress causing the shear. However when the primary stress is shear, the secondary tensile stress has a maximum value along a plane at 45° and is equal to the shear stress causing the tension. Whether or not shear displacement takes place depends on the relative ability of the metal to withstand the shear stress and at the same time resist rupture by direct pulling of the atomic layers apart in a plane perpendicular to the direction of the tensile load. This resistance to shear or building up of the tensile stress is not only an inherent property of the material but can be affected by the geometry or shape of the loaded member. In fact any set of conditions which cause an increase in the resistance to shearing displacement within the grains causes a loss of elongation in the tensile test and makes the material approach a brittle action. This may be due to cold work, precipitation of a microconstituent or a shape factor. For example, a metal tested in tension using the standard specimen which has a ratio of length to diameter of eight may show an elongation of 40%. This same material with a test length of $^1/_2$ in. or a ratio of 1 to 1 may give a value of 60% while a test length of $^1/_4$ in. or a ratio of 1 to 2 will show about 10%, Figs. 4(*a*) and 4(*b*). For a test length of zero the elongation is zero and the fracture is straight across in tension. This would then indicate that the metal was brittle but actually its inherent properties are the same, the form of the test specimen having a circular notch causing the artificial condition. This same effect is often produced by design and it can be seen that any amount of elongation, no matter how great, will not guard against this type of failure. Full appreciation is necessary on the part of the user of the fact that the ability of a material to permanently deform is not only a function of its inherent properties but also of the shape or relative value of its cross section to its length.

To permanently deform, the metal must be free to contract in a direction approximately perpendicular to the primary load. This ability can be detracted from by changing the shape as explained, or by causing a load in the direction of contraction to prevent this as by biaxial and triaxial stressing. When triaxial stressing is present of equal intensities no shear displacement can take place thus indicating a brittle material on a basis of the action at failure, this condition can be easily overlooked in design. However, in welding design except for heavy sections there is no excuse for such a condition since members can be joined to avoid this and material can be

tributed not only to avoid an unfavorable shape, but can be constructed to relieve stresses by natural flexure without plastic adjustment. For example, where several members are welded to a web of a main member in a truss, the members can be spaced so that the welds will not intersect to cause a congestion of metal. Where stiffeners are used on welded girders the corner can be sheared off so that the welds cannot be continued into the corner at the intersection of the stiffener with the flange and web, Fig. 7. In the case of stiffeners used on long or wide sections as in ship construction, the welding can be so planned that a length of plate will be free for a width including two or three stiffeners, thus increasing the length thickness ratio.

Elongation may be legitimately used to indicate that a metal or alloy has sufficient reserve plasticity to adjust itself to stresses which may develop due to unsymmetrical loading or conditions which may cause a relatively large stress locally, much larger than the statistical average computed by conventional design formulas. This local overstressing will do no harm if the material can move plastically to relieve the high stress and thus equalize conditions. Another case is that of the relieving or adjustment of the stresses induced by the natural tendency to shrink against restraining by the colder parts during the joining of metals by fusion welding. This can happen only when shear movement takes place. The ability for this to happen without permanent injury is indicated by values of elongation as obtained from the tension test, the result of slipping along the atomic planes

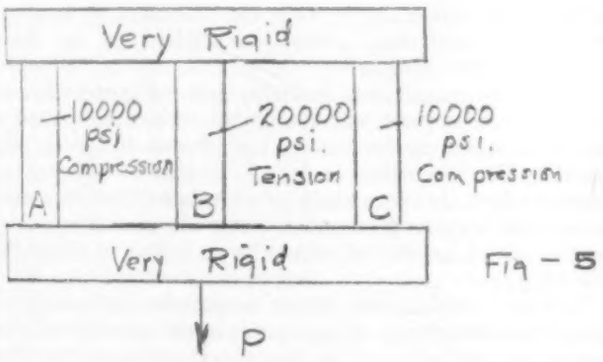


Fig – 5

of the metallic grains. However, the designer does not need to insist on the maximum values that a material can develop when such insistence may cause a sacrifice of other valuable properties or added cost. If the true stresses could be accurately predicted no ability to permanently deform would be necessary since the design could be made so that the elastic limit need not be exceeded. This condition is difficult to realize except for very thin gage sheet stock, thin wall tubing and members having relatively small diameters.

It will be supposed that the engineer or designer has specified a minimum value of elongation in per cent from experience with the material under similar conditions or simply from a feeling that this minimum value will insure against failure by some combination of conditions during service. It may be that he has picked his value on a basis of tests of material which has given satisfactory performance in service similar to that for which the design is made. It is possible that he may be correct in his choice and at the same time he may be placing the responsibility on this value of elongation and thus laboring under a condition of false security. Much work has been done and many investigations are on record which show that a given value of ductility, even

Fig. 6

though large, does not insure against failure in service.

If the attention is to be focused on percentage elongation the true value should be used. When a relatively small volume is subjected to a localized stress the material will act more like that which is drawn through a die than like the unsupported length of the standard tensile specimen. In this case the metal is capable of elongation many times that indicated in the tensile test where the stretch is taking place through a major time of the loading on a relatively restricted section. However, the percentage at break is based on the original length, much of which ceased to elongate farther after the maximum load had been reached. The actual ability to elongate or true ductility can be computed from the tensile test based on the fact that the volume of the metal does not change after the yield point has been reached. Thus it would be possible to draw the specimens out along the whole test length to a final length which would give a volume equal to the original with a cross-section area equal to that of the minimum section produced at the neck. Letting A_o equal original area of cross section, L original length, A_m final area and L length of section having same volume but cross-section area A_m, the expression for final length L is found as follows:

$$A_oL_o = A_mL; \qquad L = \frac{A_oL_o}{A_m}$$

Increase equals

$$L - L_o = \frac{A_o}{A_m}L_o - L_o = L_o\left(\frac{A_o}{A_m} - 1\right)$$

The unit elongation possible then becomes $[(A_o/A_m) - 1]$ and this times 100 gives the true percentage elongation or ductility in the true sense. For the example of steel given previously, which showed a percentage elongation for the 2-in. length of 39% and a reduction of area of 63%, the true elongation becomes $[(0.2/0.074) - 1] \times 100$ or 170%, more than four times the engineering or nominal value. The true curve plotted between true stress and true ductility is shown as *Oabfgh* in Fig. 1. With this value in mind the designer could readily accept smaller values of ductility based on the standard test. More discussion of this will be given after a consideration of possible relation between elongation and the properties which can be listed as complex.

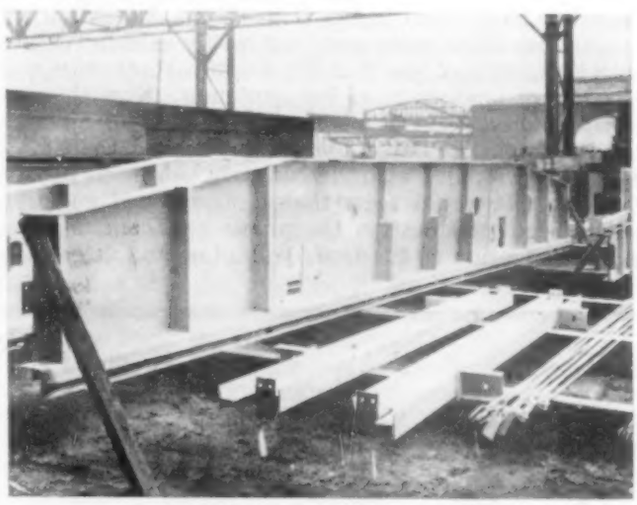


Fig. 7—Combing Girder

Table 1

	Percentages C	Mn	Si	Ni	Rockwell C Scale	Tensile Strength, Psi.	Yield Strength, Psi.	Elongation in 2 In., %	Reduction of Area, %	Impact, Ft.-Lb. Charpy	Tensile
A	0.46	0.61	0.20	3.57	52	278,000	214,000	11.5	44.3	18.0	62
B	0.47	0.70	0.24	3.55	53	288,500	214,500	11.5	34.1	5.5	9

Properties such as toughness, plasticity, malleability, resistance to repeated stress, resistance to impact, notch toughness, crackless plasticity and creep resistance involve two or more of the so-called mechanical properties found by the standard tensile test. Percentage elongation is often used to indicate, or is thought to indicate, that a material will have relatively satisfactory performance under loading producing action requiring favorable values of these complex properties. In other words, it is thought that a large value of elongation will insure satisfactory toughness, resistance to repeated stress, resistance to impact, etc. Evidence will be given to show that this is not true.

It must be kept in mind that the following discussion is not aimed at destroying confidence in the tensile test or any of the values determined thereby, but to encourage more accurate thinking and analysis in the use of these values. Designers and engineers seem to think that there is a direct relation between percentage elongation and the performance of metals under specific service conditions. In almost all cases the tendency is to demand as high a elongation as possible, frequently resulting in an impractical value. The thought seems to be that the larger the elongation the better the performance will be with regard to special stresses and applications. However, an engineer who will fight for a minimum value of 30% for a given steel will accept fifteen for a critical heat-treated part such as spring steel. He will not worry over the fact that the part may be seriously stressed internally during the heat treating and may have so-called stress raisers left in the metal or sharp corners built into it during fabrication. When malleable iron having 5% elongation was produced it was acclaimed widely because of this value. Why? Because everyone was thinking of cast materials like gray iron which had practically zero elongation. Then when malleable was produced having 10% stretch it was considered marvelous. This material was used under loading conditions where steel was required to have at least 20% elongation. An example can be given of the casting used as a part of the knee action support for the front wheels of a popularly priced automobile. This was welded to a forging which was required to have much higher elongation. Aluminum and magnesium alloys were quite commonly used as castings with elongation of less than 5% for important units such as parts of landing gears for airplanes. Now this material is universally accepted and thought to have excellent properties based on a value of less than 10%. The reason for this attitude can only be due to relative thinking. It would seem that designers and engineers might begin to question the practice of demanding as much elongation as the trade will allow and attempt to make specifications which more nearly meet the service conditions.

Example after example can be given to show that a specific value of elongation will not give assurance that an expected performance will result under a given combination of practical loading. However, only a few will be included here, references to others will be given at the end of the paper. G. C. Riegel and F. F. Vaughn[7] give values for two steels, Heat A and Heat B, shown in Table 1. These steels were as closely identical as mill practice will hold. The yield point and percentage elongation values are identical. Reduction of area and impact values vary considerably, Steel B having much lower values. However, on a basis of elongation the steels should perform equally well. It was found when one of the best of the heats having the low impact values was used to make 400 sets of gears that, for four successive years, gears from that lot failed under service conditions while those from heats having the higher impact values were free from service complaint. The following example from work by F. Bacon[15] shows a trend in the opposite direction. In this case the notched bar impact values were comparable with the ductility figures, but the notch endurance stress was higher for the lower ductility. (See Table 2.)

The same conditions, namely, lack of correlation between notch impact and elongation when subjected to repeated stress performance, are shown by work published by W. L. Collins and T. J. Dolan.[20] Other investigators show this same lack of correlation between elongation and service performance, for aluminum and magnesium alloys having relatively large values of elongation (10–12%).

Another application where engineers and designers place great weight on elongation is in the selection of electrodes for welding and in the specification of the weld metal. According to the AMERICAN WELDING SOCIETY classification the E 6010 and 6011 electrodes must have a minimum elongation of 22% in the as-welded condition while the E 6012 group must have 17% in the as-welded state for the all-weld-metal tensile test. On this basis the engineer selects the 6010 or 6011 type of electrode at the sacrifice of higher strength and faster welding speeds. It would seem that, unless other characteristics of these electrodes enter into the specification, careful scrutiny would be warranted to determine whether or not 17% elongation is sufficient or even more than required.

The paper by D. J. McAdam, Jr., and R. W. Clyne on the "Theory of Impact Testing": Influence of Temperature, Velocity of Deformation and Form and Size of Specimen on Work of Deformation[6] is well worth study by anyone who wishes to pursue the subject further

Table 2

C	Ni	Tensile Strength, Psi.	Yield Strength, Psi.	Elongation in 2 In., %	Reduction of Area, %	Brinell Hardness No.	Izod Impact, Ft.-Lb.	Endurance Polished, Psi.	Endurance Square Shoulder, Psi.
0.55	..	124,000	65,000	21	44.5	245	5	62,000	28,000
0.30	4.60	124,000	108,000	25.5	59	254	71–86	67,000	24,000

and gives many data and proof of the points which have been emphasized in this discussion. The author had the privilege in 1941 and 1942 of working on the development of a cast steel for use on armament. Exhaustive tests were made on many heats of steel of variable analyses. No correlation could be found between elongation, reduction of area or notch impact values and the ability of the steel to hold up under actual fire tests. The only correlation seemed to be between microstructure and the shock tests caused by actual projectiles. When the microstructure showed no ferritic network produced during the quenching, the steel invariably gave satisfactory results. On a basis of elongation those showing the largest values often gave the poorest test results at the proving grounds.

Figure 3 illustrates possible stress-strain action for three low-carbon steels of the same composition or for three samples of the same steel when subjected to different mechanical treatment. Steel No. 1 shows no definite yield point, but has a continuous mixed elastic and plastic action starting at the elastic limit or proportional limit which is relatively low. No. 2 has a definite yield point but a small amount of plastic action while No. 3 shows a large amount of plastic action at the yield point. For the first, the plastic range is zero, for the second about 1% and for the third about 9%. All the steels have approximately the same over-all elongation.

Curve 3 of Fig. 3 is typical of low-carbon steel commonly used for welding fabrication. For this application large values of elongation are specified to assure that the metal will have sufficient plasticity to adjust itself to the stresses set up during the shrinkage of the hot metal against the resistance of the colder metal being joined. If the design has been properly made and the welding technique controlled to follow reasonably good practice, is a large value of elongation necessary or can it be used? If poor design has to be contended with and poor fabrication technique is used no practical value of elongation will save the metal from eventual service failure. For example, the relative amount of elongation that may be necessary can be arrived at by referring to Fig. 5. It is assumed that the members A, B and C are held in a rigid frame in such a manner that B is held under a unit tensile stress of 20,000 psi. while A and C have 10,000-psi. compression much like the contracting weld metal between the joined plates. Let it be assumed that the yield point for the material of A, B and C is 30,000 psi. If a load P is applied to the unit this will build up stress until finally 30,000 psi. is produced on B thus causing yielding, meanwhile the stress will be zero in A and C since sufficient motion must have taken place between the bars to cause 10,000 psi. in A and C as well as B at the same time relieving the compression in A and C. Further loading externally by P causes the bars to move farther apart with elastic action for A and C and plastic yielding of B which it will be assumed has an engineering curve similar to 3 of Fig. 3. A motion corresponding to elastic movement of A and C to produce the yield point of 30,000 psi. in tension requires a unit elongation of 40,000/30,000,000 or 0.13%. For this particular steel the plastic elongation range is 9%, ample to take care of the adjustment. In fact if 9% were needed this would mean so much distortion that most structural members would not function practically. When all the members have been brought to the yield point, the stress is uniform, or in other words, the nonuniform internal stress condition has been mechanically relieved. When the unit is unloaded, only relatively small internal stress remains. This method is used practically to stress relieve welded pressure vessels.

If the steel of Fig. 5 had characteristics shown by Curve 1 of Fig. 3, the same action would occur except the yield point is reached at lower stress intensity. However, the adjustment would take place at higher and higher stress intensities, but the range from a to b is greater than $^1/_{10}$ of 1% and the stress corresponding to b is no higher than that for *2* and *3*. It could be possible that the progressive adjustment taking place at the lower value might relieve stress concentrations before they could do permanent damage such as might occur when a crack starts at the root of a notch or in the region of a flaw or inclusion. In fact it would appear that action depicted by Curve *1* of Fig. 3 is very desirable for stress relief so that a careful interpretation of the tensile stress-strain diagram may give the necessary solution for many applications seeming to have no correlation with it at present. Then, too, it is not unreasonable to imagine that metal could be produced at will which would have given characteristics to aid stress adjustment. It has been shown that the elongation of structural steel and metal deposited by welding is far in excess of that needed for practically all construction. By proper designing to eliminate contour and congestion of points which might cause large stress concentration, high elongation is not necessary. When this is done, a structure and machine will actually operate with stress distribution more nearly that which the designer intended. Thus elongation fades in importance as a specification in comparison with other advantages to be had by not limiting design by insisting on large values of ductility. Thus for various welding applications the designer will not be limited to one type of electrode, but can choose the one which was designed to work best for a particular application. Further, it may then be possible to engineer the fabrication so that a faster more specialized electrode can be used. For example, assume that the requirements have resulted in the design of a machine frame or beam having an I-cross section which is to be made by welding together three plates as shown in Fig. 6 using fillet welds. On a basis of ductility an E 6010 type of electrode would be chosen, whereas the E 6012 is ideally suited for this application and has more than sufficient ductility. If the design requires the use of $^1/_4$-in. fillets, the weld can be made in the flat position at 40 ft./hr. with an E 6010 $^1/_4$-in. electrode and at 55 ft./hr. with an E 6012. Figure 8 shows a group of truck frames where distinct savings were realized by using the E 6012 electrode.

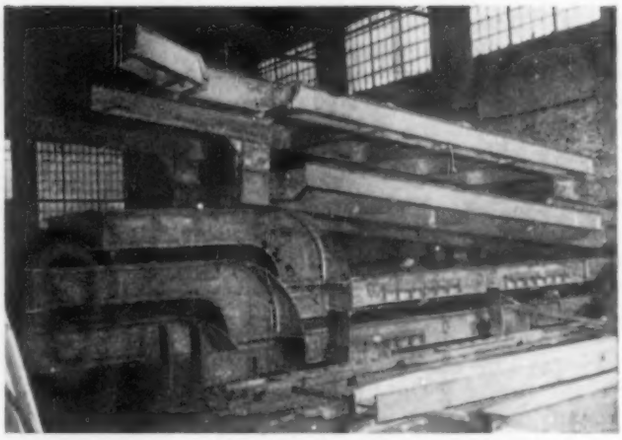


Fig. 8—Truck Frames

The saving need not stop here, since due to the higher travel speed, the full force of the arc is available for penetration. By this means more of the base metal is fused to produce a stronger or equally strong joint with smaller size welds in the case of fillet welds especially when made with the specialized electrode. Using more of the

base metal to carry the stress makes it possible to effect a metal saving. The intent has been to show that the selection of a material in design simply on the basis of one characteristic such as ductility will greatly limit the possible choice and application and may add greatly to cost. The latter is an important fact to keep in mind since modern industrial trends indicate that we are on the way to an era of keen competition so that only the most efficient producers of a given product will survive. The efficiency not only entails the ability of the structure or machine to properly function in service, but also the ability to fabricate the product at a minimum cost.

Design for welding is especially susceptible to analysis from the point of low cost since the flexibility in the fabrication allows the designer great freedom in the distribution and method for joining metal. If full advantage is not taken of these facts, much of the savings possible by this process may not be realized. When too much attention is given to arbitrary specification such as the choice of a given value for ductility, application of materials, use of a process or a particular design may be limited. Therefore, advantage cannot be taken of valuable characteristic methods or procedures. For example, if electrodes were to be chosen on basis of elongation values and a large value of this property insisted on, the welding fabricator may be greatly handicapped. On this basis, the A.W.S. E 6011 or 6010 type will be specified. Making a weld on plates to form a T joint by means of a single pass fillet weld with the selection limited to the E 6010 electrode on a basis of elongation will add considerably to cost as compared to the possibilities using the lower elongation E 6012 type. As pointed out, greater efficiency can be realized by going all the way by using the specialized electrodes wherever the application will allow and can be engineered to that end illustrated by the base of Fig. 9. It has been possible to only scratch the surface of such a topic as this and stay within reasonable bounds as far as space is concerned. If this treatise causes engineers and designers to think more carefully about the meaning of elongation and to question the advisability of large values when not needed, and if it causes them to analyze their problems more profoundly the author will feel well repaid.

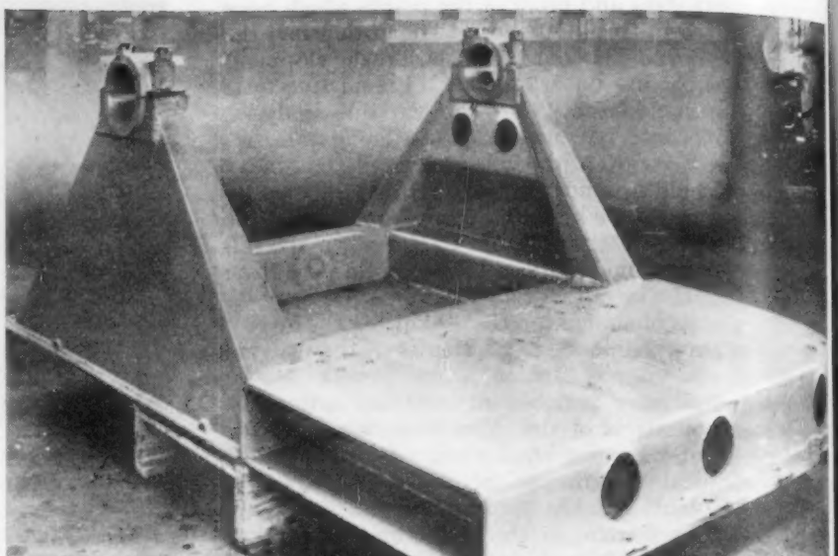


Fig. 9—Hoist Base

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BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for our Armed Forces at war and for continued improvements and economies in your telephone service

RESEARCH, in the Bell Telephone System, has always been an expanding activity, growing with the scientific knowledge of the times and contributing to that knowledge. Upon it have been based important inventions and developments.

The telephone, itself, was invented in the laboratory where Alexander Graham Bell was carrying on researches in speech and hearing and laying the foundation for the electrical transmission of speech. As time went on the telephone research program expanded to cover every science which gives any promise of improved telephony and every engineering art which applies to the development, construction, installation and operation of telephone facilities.

These researches and development studies now cover electrical communication of speech—both by wire and by radio—the transmission of pictures (television)—and many important projects for war.

There Is No End to Progress

Every new research gives rise to new inventions and to new lines for development and design. New inventions indicate new lines for more research. Research and development work, invention and design go hand in hand. In the early years, this work was carried in part by the American Telephone and Telegraph Company and in part by the Western Electric Company, the manufacturing unit of the Bell System.

For many years, however, this work has been assigned to a specialized unit, Bell Telephone Laboratories, Incorporated. Theirs is the responsibility for the technical future of the industry. They carry their developments from the first faint glimmerings which basic researches disclose to the final design of equipment and the preparation of specifications for its manufacture. And after manufacture and installation, they follow their products in operation; and continue development work to devise still more perfect equipment, less expensive, more convenient and of longer useful life.

These policies and procedures of Bell Telephone Laboratories are distinguished by two characteristics. In the first place the Laboratories design for service. The consideration is not the profit of a manufacturer through first sales and replacement models but the production of equipment which will give the best service at the lowest annual cost when all factors are considered, such as first cost, maintenance, operation, and obsolescence. The Laboratories make no profit and the equipment they design is owned and used by the telephone companies; and the emphasis is upon that use.

Organized Co-ordinated Research

In the second place the Laboratories design always with reference to the complete communication system in which the particular equipment is to play a part.

Reliable, economical telephone service, which is the product of its efforts, is not so much an assemblage of excellent apparatus as it is an excellent assembly of co-ordinated equipment—all designed to work together reliably and economically for a larger purpose.

It is not enough that Bell Laboratories shall design a new piece of electronic equipment which has merit or a new cable or telephone receiver. They must design with reference to all the other parts of the communication system so that the co-ordinated whole will give the best possible service.

4600 People in Bell Laboratories

Bell Laboratories contributions to the Armed Forces derived in large part from the technical background that the Laboratories had acquired through their steadily maintained program of research. The Laboratories had special knowledge, skill and techniques which could instantly be diverted to war problems.

At the time of Pearl Harbor, over a quarter of the 4600 people in the Laboratories had twenty or more years of service. This breadth of background made possible many engineering developments outside the strict field of communication and these have been of value to the Armed Forces. So far the Armed Forces and the O.S.R.D. have engaged the Laboratories on over a thousand major projects. The majority of these assignments have been completed; and have contributed to our victories on many fronts.

Most of the Laboratories developments, of course, have been in the field of electrical communication. Communication, not simply between individuals as in ordinary telephony, but between mechanisms—as in the electrical gun director. The Laboratories techniques and electronic researches have produced many secret weapons for our country's Armed Forces.

Leader in Electronic Development

For those problems the Laboratories had a remarkable background of experiences in research and development. In World War I, they pioneered by developing radio telephone systems for talking between planes and between planes and ground stations. They also contributed methods and devices for locating enemy planes, submarines, and artillery.

In this war, Bell Laboratories have pioneered in the field of electronics. The Western Electric Company, which manufactures the designs of the Laboratories, is the largest producer of electronic and other war communication equipment in the United States and is now engaged almost exclusively in the manufacture of this equipment.

In war, Bell Telephone Laboratories devote their work to the needs of our Armed Forces. In peace, they are constantly exploring and inventing, devising and perfecting for continued improvements and economies in telephone service. Centralized research is one of the reasons this country has always had "the most telephone service and the best at the least cost to the public."

BELL TELEPHONE LABORATORIES

THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

A.S.T.M. MEETINGS

1945 Spring Meeting, Pittsburgh, Hotel William Penn, Feb. 28, 1945.

A.S.T.M. Committee Week, Feb. 26 to Mar. 2, 1945, Pittsburgh, Hotel William Penn.

1945 (Forty-Eighth) Annual Meeting, Buffalo, Hotel Statler, June 18 to June 22, 1945.

Philadelphia District—Symposium on Magnetic Particle Testing, Jan. 22, 1945, Hotel Benjamin Franklin, Philadelphia.

New York District—Petroleum and Some of Its Modern Derivatives, Jan. 17, 1945, Engineering Societies Building, New York.

Philadelphia District—Symposium on Experimental Stress Analysis, April 12, 1945, Franklin Institute, Philadelphia.

BUDD HONORED

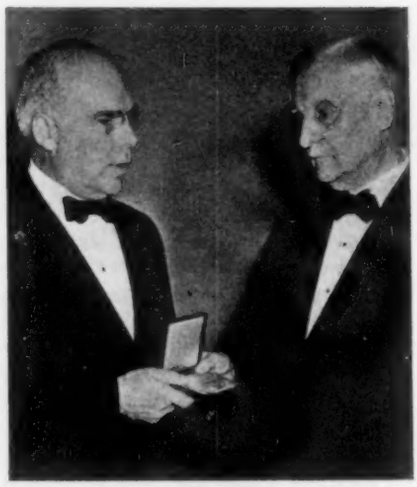
Edward G. Budd, founder-president of the Edward G. Budd Manufacturing Company of Philadelphia, on Nov. 28th, was honored by the award of the A.S.M.E. Medal at the annual dinner of the American Society of Mechanical Engineers held at the Hotel Pennsylvania. The Award was presented "because of his outstanding engineering achievements."

The Budd Company pioneered in the field of steel automobile bodies which have since been universally adopted. Budd also designed and perfected the first steel disk wheel for automobiles.

Another "first" of the Budd Company is the Shotweld process of fabricating stainless steel which made possible the use of that metal for the building of streamlined railroad cars and truck trailers. The first streamlined, lightweight train on which this process was used was originally christened "Burlington Zephyr" which was completed on April 18, 1934. This train, now renamed the "Pioneer Zephyr" and generally considered by railroad men to be the "father" of all lightweight trains, is currently making a 456-mile round trip daily between Lincoln and McCook, Neb., having covered a total of 1,782,225 miles since going into service. More than 500 lightweight, Budd-built, stainless steel railroad passenger cars were put into operation before the war stopped production.

According to the citation accompanying the A.S.M.E. Medal, Mr. Budd "was the leader in the construction of streamlined, lightweight railroad passenger trains with their many innovations. In connection with his development of the steel automobile body, he perfected the design of many intricate dies for forming sheet metal by deep-drawing."

The company's plants in Philadelphia and Detroit are now engaged in filling government orders for munitions for every branch of the country's armed forces.



Budd Receives Award

Robert M. Gates, President of the American Society of Mechanical Engineers, left, presents the A.S.M.E. Medal to Edward G. Budd, president of the Edward G. Budd Manufacturing Company of Philadelphia, Pa., at the annual dinner of the American Society of Mechanical Engineers at the Hotel Pennsylvania.

SETTING UP WELDING BUSINESS

The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio, has issued a pamphlet, entitled "Setting Up and Operating a Welding Business."

The material comprising this pamphlet consists of three award-winning studies from Foundation award programs. Particulars of the contents are as follows:

"Developing and conducting a Commercial Welding or Job Shop," by Fred H. Drewes, Welding Engineer, W. P. Thurston Co., Engineers and Contractors, Richmond, Va.

"How to Use the Arc to Increase Business in the Garage," by E. W. Weinberger, Owner, Weinberger's Garage, Mott, N. Dak.

"Organization of Garage or Service Station Using Arc Welding," by Clarence McClellan, Director of Welding, McClellan and Sons Super Service Station, Menominie, Wis.

NEW ACETYLENE GENERATOR BULLETIN

Air Reduction, manufacturer of welding equipment and gases, has issued a new bulletin on acetylene generators. It features the new Airco Type "P" Portable Generator, incorporating an "air lift" water circulating system and enlarged radiation space between the carbide hopper and water level which eliminate the "hot belt" and provide cooler, double-scrubbed gas.

The bulletin describes and illustrates the company's complete line of generators, including portable models in 15-, 30- and 50-lb. sizes with 30, 60 and 100 cu. ft. maximum hourly productive capacity. Stationary models are available in 300- and 500-lb. sizes which deliver 300, 600 and 1000 cu. ft. maximum hourly production.

Copies of the bulletin, which also lists sizes and packaging of National Carbide for use in acetylene gas production, may be obtained from any Air Reduction office or by writing the company's general offices at 60 E. 42nd St., New York 17, N. Y.

BOOKLET DEFINES RESISTANCE WELDING EQUIPMENT STANDARDS

A new booklet just published by the Resistance Welder Manufacturers' Association, 505 Arch St., Philadelphia, Pa., standardizes the nomenclature, definitions and quality of resistance welding equipment.

A chart is included giving the proper electrodes to be used for spot welding similar and dissimilar metals.

Under Electrical Standards are tables of Equivalent Ratings, limits of Transformer Temperature Rise, etc.

Whether you are now using resistance welding processes or plan to use them in the future, the booklet is one which will prove decidedly useful. A copy will gladly be sent free on request to the Association.

PLUG WELDED ALL-MONEL LINING

provides sound, corrosion-resistant inner surface for steel heat exchanger shells used in oil refinery

A welded-in all-Monel lining licks many a corrosion problem. Such linings are readily installed, as the accompanying photographs of a finished job illustrate.

Pictured are two of five large steel heat exchanger shells, lined by John Dollinger Jr., Inc., Beaumont, Texas, for a Gulf Coast oil refinery. Each shell is 34" ID x 15' 4⅞" long, and is lined with .078" Monel sheet, plug welded on 6" centers. The plug welds, as well as joint butt welds, are done with the same rod ... No. 130X Monel Arc Welding electrodes ... giving a strong, continuous, all-Monel inner surface.

The accompanying guide for welding in Monel linings is condensed from the INCO Technical Bulletin, "Welding, Brazing and Soft Soldering of Monel, Nickel and Inconel." For a copy or copies of this 32-page booklet, write for *BULLETIN T-2.*

STEEL HEAT EXCHANGER SHELLS, *34" ID x 15' 4⅞" long, lined with .078" Monel sheet, plug welded on 6" centers. Plug and joint butt welding both done with No. 130X Monel Arc Welding electrodes, producing firm strong, all-Monel inner surface. Lining by John Dollinger, Jr., Inc., Beaumont, Texas.*

FOR A BETTER WELDING JOB when putting in Monel tank linings:

PREPARE ALL AREAS to be welded by sandblasting or spot grinding down to clean steel.

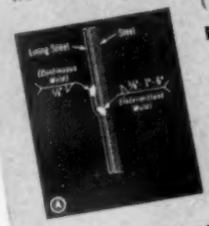
USE SHEETS AS LARGE as practical to reduce the amount of welding, cleanly punched with ⅝" holes for plug welding. Roll sheets to the tank radius, with the longest dimension circumferential for large diameter tanks, but for heat exchangers, see large photograph at the top of this page.

COMPLETE THE TOP course first. Hold the first sheet firmly in place with air jacks, etc. Next, tack the lining sheet at every 3rd, 4th or 5th hole by welding to the steel at across the bottom of the hole (the sheet *must* be held only against the shell). After the general tacking of the sheet, attach the edges to the steel by welds 1" to 2" long and 6" apart. Weld from the top down.

Or, the punched sheet may be positioned and held firmly against the shell, then row after row of plug welds completed, and finally, the edge of the sheet welded to the steel.

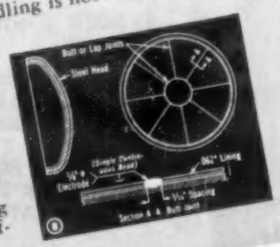
POSITION THE ADJACENT sheet, lapped ½" to 1" over the first, and tack or weld. Then weld in a continuous Monel-to-Monel lap joint. Lap joints are used mostly for tank linings; however, butt joints can be used also.

INSTALL THE SECOND course, after completion of the top course, in the same fashion. Offset the top of each second course sheet to provide a convenient shelf for the lap seal weld of the horizontal, continuous joint. Weld intermittently around each second course sheet. (See Sketch A.)



PLUG WELD either of 2 ways (1) Weld only around the outside of the holes until a line of holes has been welded. Then remove welding slag, check the welds for a bond to the steel, and fill the holes with a short Monel weld, made in a straight line or with a slight weave rather than just puddled in. (2) Fill the holes completely in one pass by welding all around the edge, then filling in the center. Again, puddling is not recommended.

TO LINE DISHED HEADS, cut pie-shaped segments carefully to accurate template, then form them to the head contour, and butt weld. A center circle, 12" to 24" in diameter, simplifies fitting at the middle of the head. (See Sketch B.)



LINE FLAT COVER by using either lap or butt joints, preferably lap.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

NICKEL (INCO) ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL
INCONEL • "Z" NICKEL • NICKEL

Sheet...Strip...Rod...Tubing...Wire...Castings...Welding Rods (Gas & Electric)

TWECO CATALOG

The New 1945 "Twecolog," a 12-page catalog, describes fully the complete line of cable connections for electric welding as manufactured by Tweco Products Co., English at Ida, Wichita 7, Kan.

Items shown in the 1945 "Twecolog include Electrode Holders, plain and insulated, Ground Clamps, Cable Connectors, Machine Terminals and Cable Lugs. All items in the catalog are clearly described and priced. The three back pages of the "Twecolog" are devoted to a complete Quantity Price and Parts List. Some items are reduced in price.

The 1945 "Twecolog" is available to those desiring a copy by writing the manufacturer or through their local distributor of Tweco Products.

LOW TEMPERATURE BRAZING NEWS

Low Temperature Brazing News No. 29 issued by Handy & Harman, 82 Fulton St., New York 7, covers a subject of vital inte est to the thousands of plants that are now using silver brazing alloys. It points out how the preplacement of SIL-FOS and EASY-FLO can save time and money by simplifying and speeding up brazing operations. Copy available on request.

HERCULES ELECTRIC OPENS NEW PLANT

The Hercules Electric and Manufacturing Corp., manufacturers of D.-C. and A.-C. Welders, Transformers, Coils, Magnetic Clamps, Solenoids, Rivet Heaters, Spot Welders, Fluorescent Bellasts and Special Controls, announces that they are now located in their new plant and offices at 2500 Atlantic Ave., Brooklyn 7, N. Y., where their expanded facilities will enable them to better serve the requirements of their trade.

CAST METALS HANDBOOK

Cast-Metals Handbook, 3d revision, 1944. Published by American Foundrymen's Association, 222 West Adams St., Chicago 6, Ill. Cloth bound, 745 pages, 258 illustrations, 204 tables, Price $6.00.

The 1944 edition of the A. F. A. *Cast Metals Handbook* represents a most extensive revision from the previous edition (1940). It deals exclusively with the engineering properties of cast metals and has been prepared especially for use by those who design metal parts and who specify or purchase case metals for industrial products.

The book includes considerable information of value to designers of castings, showing numerous examples of specific structures where redesigning has made possible a greatly improved cast product. Included are recommendations to buyers of castings that should answer many problems of the manufacturing purchasing agent. A section also is devoted to the significance of strength and ductility tests of metals, covering such tests as resistance to fracture, creep strength, hardness, static and dynamic ductility, corrosion fatigue, wear, etc.

Separate and extensive sections deal with Steel, Malleable Iron, Cast Iron, and the Non-ferrous Alloys, all technical data included having been brought up to date in the light of cast metals development made since publication of the previous edition. The book is intended for long range use rather than simply to cover specifications made necessary by wartime shortages of and restrictions on metals. However, conforming specifications (A.S.T.M., Federal, Navy, S.A.E., A.M.S. and Bureau of Ships) are shown for both ferrous and nonferrous products.

The Technical data given were prepared and approved by committees of the American Foundrymen's Association, composed of many outstanding authorities on cast metals and foundry practices. Extensive bibliographies are included for each of the various cast metals sections with the many references to both American and foreign foundry practices adding to the value of the book for research purposes.

The new *Cast Metals Handbook* has long been recognized as a standard treatise on

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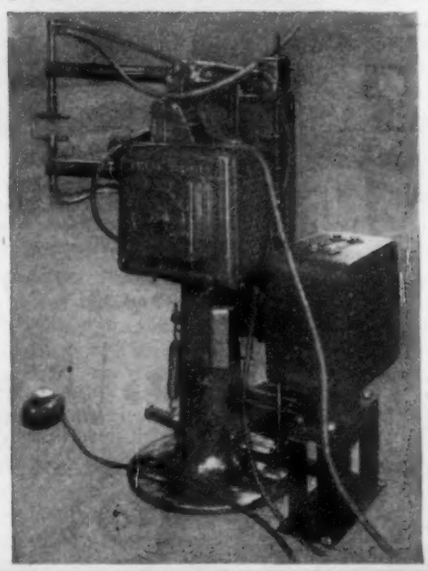
MODERNIZE YOUR FOOT OPERATED SPOT WELDER
THE MAN WHO USES HIS HEAD GETS AHEAD

SPOT WELDERS —
STOP USING YOUR FEET



SOLENOID OPERATED 20KVA TAYLOR SPOT WELDER

By the quick, simple attachment of a Hercules Special Solenoid, which operates the arms electrically, your slow, tiresome, foot operated spot welder becomes an efficient, speedy automatic machine. The results are startling:

INCREASES PRODUCTION—30% TO 50%.

INSURES UNIFORM, PERFECT SPOT WELDS AUTOMATICALLY.

A—BY PRODUCING MUCH GREATER PRESSURE ON THE ELECTRODE ARMS.

B—BY GUARANTEEING UNIFORM PRESSURE AT ALL TIMES.

CUTS POWER COSTS.

CUTS LABOR COSTS.

ELIMINATES STRENUOUS FOOT WORK.

SKY ROCKETS THE VALUE OF YOUR SPOT WELDERS.

Units are easily attached to all makes of spot welders and are available with or without automatic timers.

SUBMIT YOUR PROBLEMS OR SEND FOR DETAILED INFORMATION.

hercules

OTHER PRODUCTS MANUFACTURED BY HERCULES ARE:

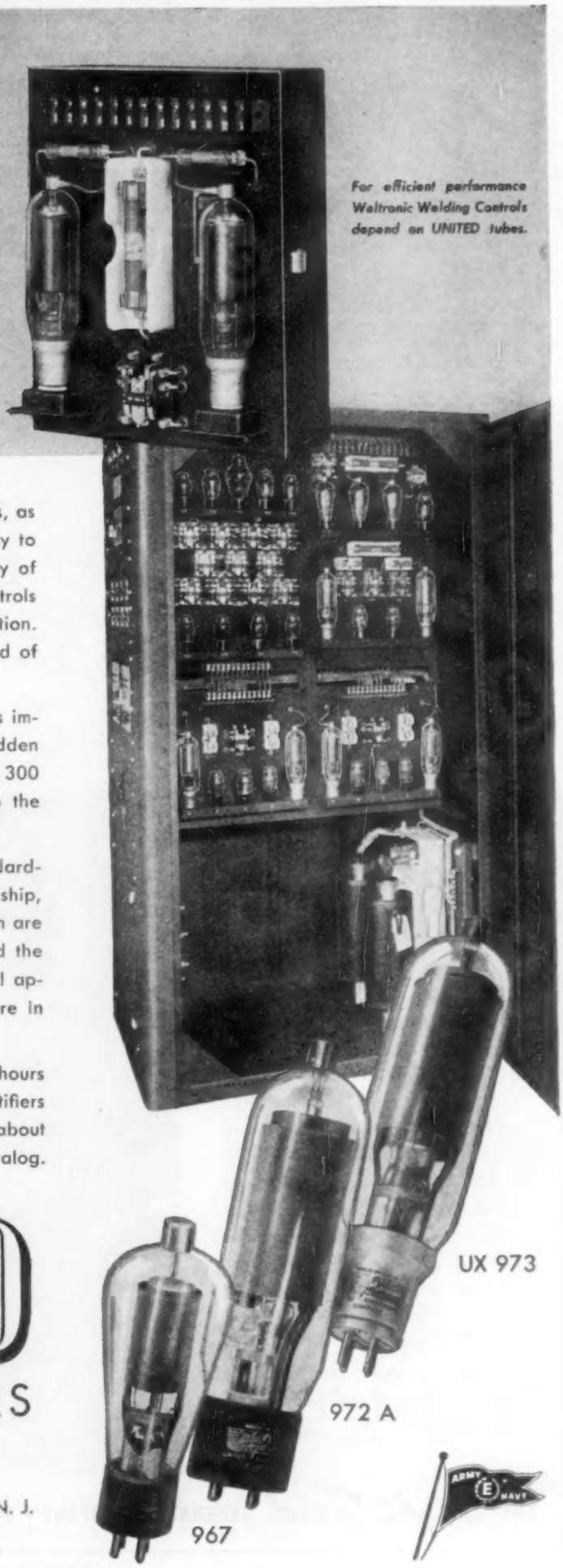
AC-DC RECTIFIERS
MAGNETIC ALIGNERS
ARC WELDERS

WRITE FOR LITERATURE

HERCULES ELECTRIC & MFG. CO.
MANUFACTURERS OF THE PRECISION WELDER WITH THE STREAMLINED ARC
2416 ATLANTIC AVENUE, BROOKLYN 33, N. Y.

300 WALLOPS a minute

but still these tubes keep going



For efficient performance Weltronic Welding Controls depend on UNITED tubes.

For better and more precise control of stop-and-go currents, as in resistance welding, mechanical methods have given way to electronics. For this application the WELTRONIC Company of Detroit, Michigan, builds Electronic Timers and Welding Controls distinguished for their fine construction and efficient operation. In the heart of these units lies the toughest proving ground of tube stamina.

The rapid and instantaneous changes in load conditions imposed on the power tubes in this function would bring sudden death to tubes built to ordinary standards. Impulses up to 300 per minute are commonplace and put the best tubes to the severest test.

For this gruelling job WELTRONIC Engineers have standardized on United Mercury Rectifiers. Their sterling workmanship, unusual physical ruggedness and excellent electrical design are the reasons underlying this preference. Built to withstand the continuous, severe conditions of these and other industrial applications, tubes by United are appearing more and more in important places.

Where the going is extra tough and several thousand hours of dependable service are essential . . . United Mercury Rectifiers are demonstrating their superior qualities. Get the facts about these better tubes today. Write for a copy of our latest catalog.

UNITED

MERCURY RECTIFIERS

UNITED ELECTRONICS COMPANY • NEWARK 2, N. J.

Transmitting tubes exclusively since 1934

the engineering usefulness of all cast metals, and as such should be of interest and value to all mechanical, product and designing engineers.

SAFETY EQUIPMENT

American Industrial Safety Equipment Co., 397 Bridge St., Brooklyn, N. Y., a division of The Burdett Oxygen Co. of Cleveland, Ohio, has just published its new catalog of "Eye Gard" and "Body Gard" products.

This is fully illustrated and gives complete details about their comprehensive line of Goggles, Lenses, Spectacles, Respirators, Rubber Gloves, Asbestos Gloves, Helmets, Hand Shields and related items.

Free copies of this catalog are available upon application to the above.

"CORROSION"

"Corrosion," a 54-page publication issued by The International Nickel Company, is a convenient and comprehensive analysis of corrosion principles for both the practical man and the technician in the metal field. It has been prepared in the belief that a good working knowledge of corrosion is the best possible means of securing maximum equipment life and minimum maintenance costs in situations where this destructive process must be taken into consideration.

An opening section explains how corrosion processes work, and discusses all the known factors that influence their action: acidity of solution, oxidizing agents, temperature, agitation, films, inhibitors, surface conditions, stress, heat treatment, welding, concentration cells and galvanic action. These discussions are illustrated with graphs, drawings and tables.

The detailed review of testing methods that follows tells how service conditions are simulated in corrosion research. Included is a description of the construction and use of the well-known spool-type specimen holder for determining the comparative behavior of several metals and alloys simultaneously under actual operating conditions.

The applicability of Monel, nickel and Inconel in various corrosive media is analyzed in the closing section of "Corrosion." Tables list nearly 500 typical corrosives in which these alloys have been successfully used, and report the results of more than 120 specific tests under varied conditions in 44 common corrosive agents.

"Corrosion" will be sent on request to equipment designers, engineers or other metal users, by The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

METALS AND ALLOYS DICTIONARY

Metals and Alloys Dictionary, by M. Merlub-Sobel, Ph.D. Over 10,000 useful metallurgical terms. This up-to-date reference work contains definitions of metallurgical terms, composition, properties and uses of the important commercial alloys. It gives the physical constants and properties of chemical elements, description of machinery and processes used in modern metallurgy, and other pertinent information. It is designed for the use of all those who want to know about the applications and peculiarities of metals, alloys and raw materials used in metallurgy. Published by Chemical Publishing Co., Inc., 26 Court St., Brooklyn, N. Y. Price $4.50.

OXYACETYLENE PIPE-LINE INSTALLATIONS

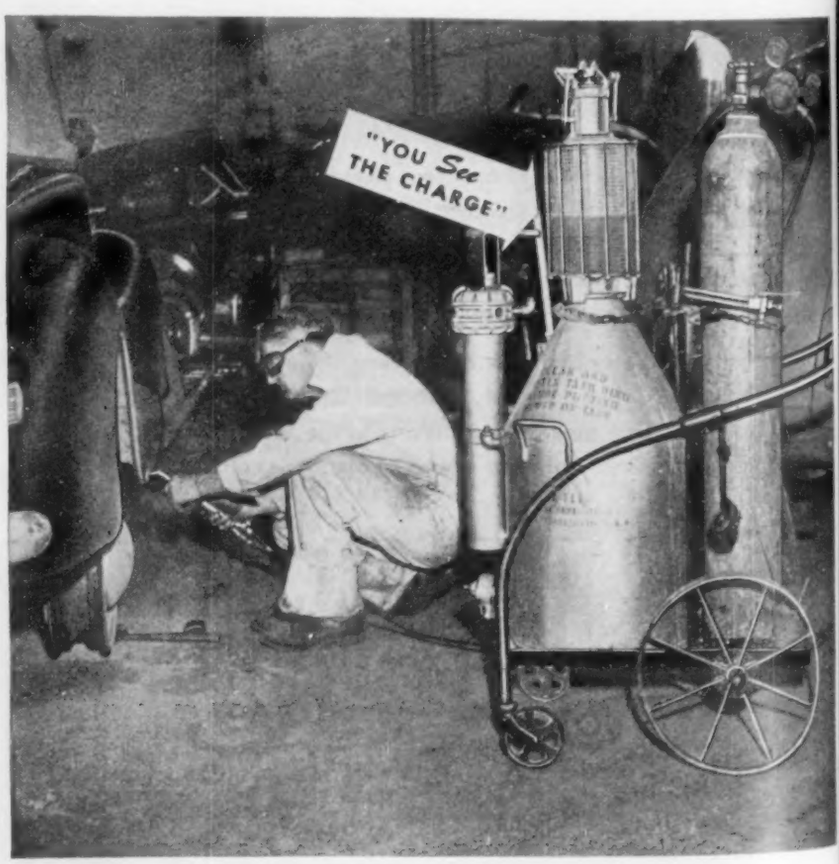
A new 12-page illustrated booklet, "Oxyacetylene Pipe Line Installations," has been issued by Air Reduction, manufacturers of industrial and rare gases and welding and cutting equipment. The booklet gives a concise description of typical oxyacetylene pipe-line plans for various size industrial plants. Written by members of Air Reduction's Engineering Staff, it discusses in detail the advantages of gas piping systems for medium- and large-volume users of oxygen and acetylene.

Economize in '45

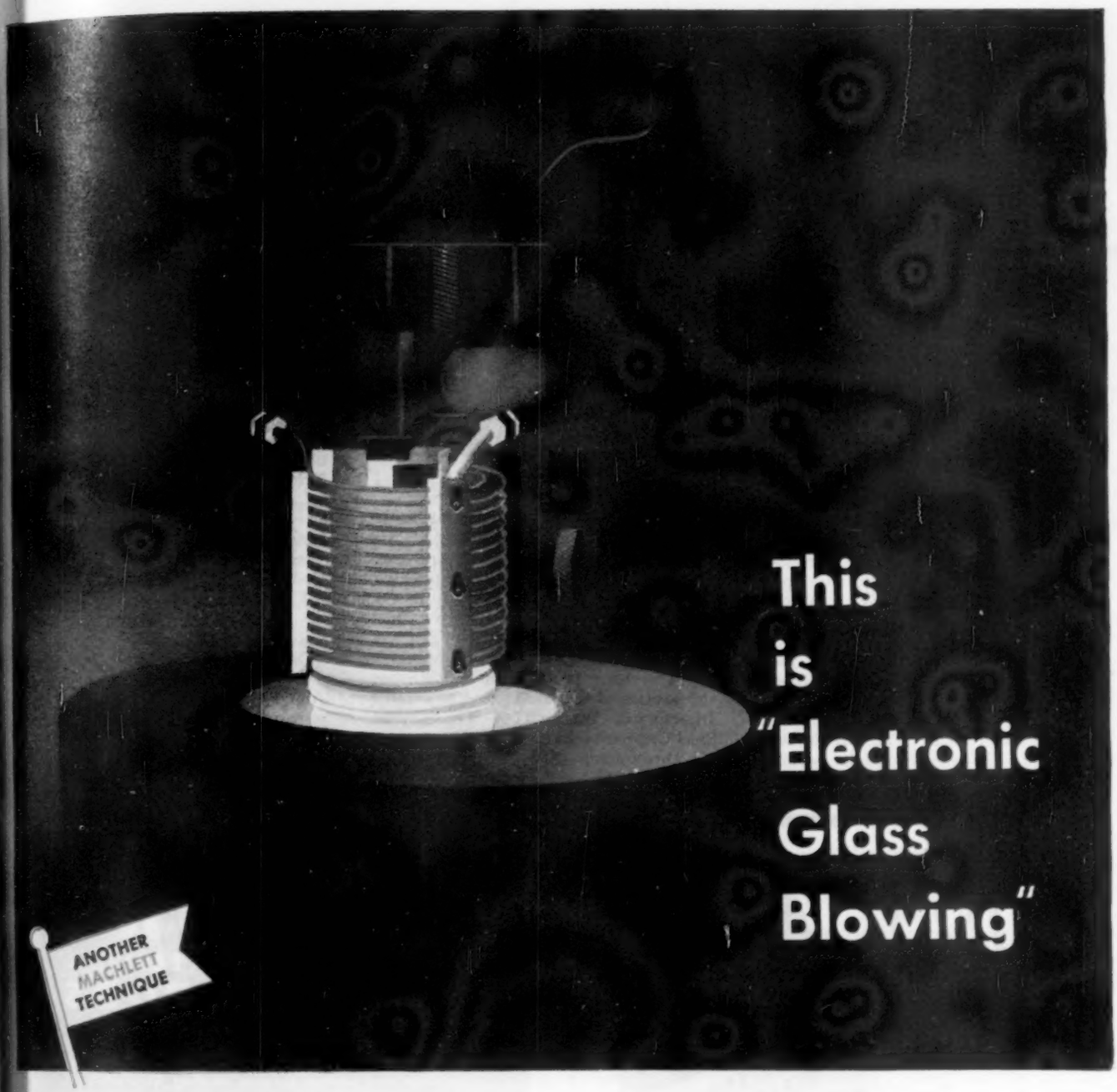
USERS of acetylene gas for welding and cutting spent around 85 million dollars for acetylene in 1944. That's a lot of money in anyone's language—spent by the many thousands of users of acetylene in cylinders.

And if all of those users had Sight Feed Acetylene Generators their acetylene costs would have been reduced 50% to 75%. Yes, their savings would have averaged at least two-thirds—a grand total of over 56 million dollars saved.

Why not order *your* Acetylene Sight Feed Generator today—and *economize in '45!*



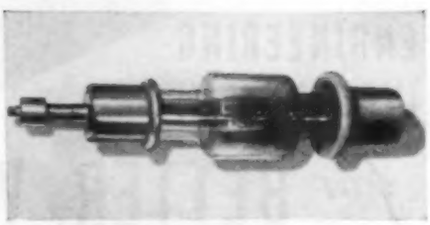
THE *Sight Feed* GENERATOR COMPANY • SALES: RICHMOND, IND. • FACTORY: W. ALEXANDRIA, O.



A group of scientists recently designed a vacuum tube of great potential usefulness. It required a long, air-tight column made with a large number of alternate rings of glass and metal, and conventional methods of glass blowing offered no promise whatever. When asked what could be done, Machlett cast aside precedent, as it often does, and devised a way of producing the "impossible" column.

Here it is. On top of a ring of glass is placed a ring of one of the special alloys that have the property of fusing with glass. Another glass ring goes on top of this. A high-frequency induction coil is lowered over this sandwich, heating the metal so not that the glass is softened to exactly the right degree for formation of a perfect fused joint, when supplemented by other glass-working techniques. Another sandwich on top of the first is treated in the same manner, and so the column grows.

Induction heating often makes the impossible practical; this is an example of that, and of Machlett's willingness to tackle baffling problems. If you have a vacuum tube problem (X-ray or radio) see Machlett. Skill of this type stands back of every Machlett X-ray and radio tube, including the one illustrated above . . . Machlett Laboratories, Inc., Springdale, Connecticut.



Machlett IR-250 tube for industrial radiography and fluoroscopy of welds and heavy materials.

MACHLETT

X-RAY TUBES SINCE 1898

TODAY THEIR LARGEST MAKER

in welding, cutting and other flame processes.

Details on pipe sizes, central depot location, station outlets, safety devices and other pertinent data are included. Schematic diagrams of piping layouts for typical plants ranging from railroad shops to aircraft welding departments are among the many interesting topics discussed.

Free copies of the booklet may be secured by writing to Air Reduction, 60 East 42nd St., New York 17, N. Y.

OBITUARY

Dr. Thomas Swinden (1886–1944)

To the deep sorrow of all who knew him, Dr. Swinden died suddenly while at the Stocksbridge Works of Messrs. Samuel Fox & Co. Ltd. in the early afternoon of Friday, Oct. 27, 1944. He left a widow and two sons.

Born in Sheffield on Aug. 15, 1886, he received his first schooling at the Central Secondary School, Sheffield, continuing his education at Sheffield University where he obtained an Associateship in Metallurgy in 1905, being a Mappin Medallist and a City & Guilds Bronze Medallist. Subsequently he won the 1851 Exhibition Scholarship for the years 1906–08, studying at Sheffield, Stockholm and Upsala. He graduated as B.Met in 1907, M.Met in 1908 and D.Met in 1913. From 1909 to 1913, Dr. Swinden was a Carnegie Research Scholar, winning

Dr. Thomas Swinden

the Carnegie Gold Medal. He was also a Freeman of the Cutlers' Company.

As to his career, after some experience with Dr. Longmuir in consulting practice, Dr. Swinden joined Samuel Fox & Co. Ltd. of Stocksbridge in 1909 as Chief Chemist, subsequently becoming Chief Metallurgist and later Works Manager and Director. In 1932, he relinquished the position of Works Manager to become Director of Research of The United Steel Companies Ltd., while still retaining his Directorship of Samuel Fox & Co. Ltd., an associate company of The United Steel Companies Ltd. He was also a Director of the Distington Hematite Iron Co. Ltd. and of the British Magnesium Corporation Ltd.

The combination of practical experience in laboratory and works management and in steelmaking, with his scientific training and bias, made Dr. Swinden an outstanding personality ideally fitted for the highly responsible position of Director of Research. The Central Research Department at Stocksbridge, which was his headquarters, bears the hallmark of the care with which he planned it. It contains probably one of the finest sets of equipment to be found in an industrial laboratory in this country, and the same care was devoted to the selection of the scientific staff, which under his guidance has become a most effective team.

Following his early pioneer work on tungsten and molybdenum steels, Dr. Swinden made very many contributions to technical literature, which earned for him the much prized distinction of the Bessemer Gold Medal of the Iron and Steel Institute, the M. C. James Gold Medal of the North East Coast Institution of Engineers and Shipbuilders and the Silver Medal of the Institution of Marine Engineers.

Dr. Swinden's activities, however, did not end with his direct duties in The United Steel Companies Ltd. To keep abreast of current research and to make a fitting contribution to the common pool of knowledge, he was a member of the Iron

FREE

ENGINEERING INFORMATION *for* BETTER WELDING

This New Engineering Bulletin contains important technical information that may save you time, labor and money on many welding jobs. Learn how to keep welding jigs free of spatter; how to save mill-scale cleaning time after normalizing; how to reduce fumes; etc. etc. Contains actual case histories and laboratory authenticated reports. Write for your copy now.

WELDING SUPPLY DISTRIBUTORS AND SALESMEN WANTED

The MIDLAND PAINT & VARNISH CO.

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Reach for DUCTONE (E6011) AC (E6013) WELDING RODS

Available again, after three years of war service. DUCTONE AC rods are designed and manufactured especially for AC welding. It is the best rod for all position and general purpose welding. DUCTONE AC rods have deep penetration, are good on dirty materials and operate on exceptionally low current. Small sizes are especially good for thin sheet metal. Excellent for vertical and overhead welding on DC positive polarity. Extruded in all sizes from 1/16" to 1/4". See your dealer.

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DUCTONE AC ELECTRODES

Chicago Steel and Wire Co.
103rd St. and Torrence Ave.
Chicago 17, Illinois

Reach for DUCTONE AC Welding Rods

EVERY JOB IS *Smooth sailing* WHEN YOU USE

CHAMPION

WELDING ELECTRODES

★ CHAMPION electrodes have what it takes to do non-position, flat and fillet welding quickly and with minimum effort. Many veteran welders know from experience that they can depend upon CHAMPIONS for quality, uniformity and all round satisfaction. During the year 1945 you can make no better choice than CHAMPION electrodes for they are all the name implies.

WELDING CHAMPION ELECTRODES

THE CHAMPION RIVET CO.

11400 Harvard Avenue, Cleveland, Ohio

EAST CHICAGO, IND.

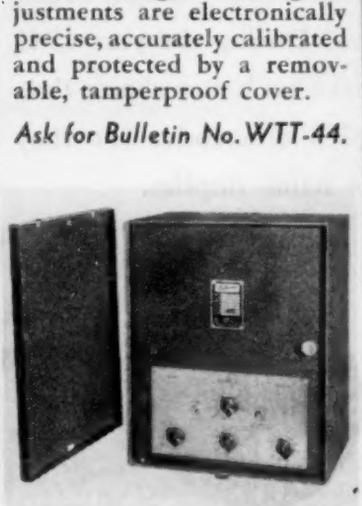
electronic Weltronic bulletins

Universal Timer Speeds Up Welder Conversion

Quick change-over from one type of resistance welding to another requiring a different NEMA standard type of timing is now possible by merely plugging in the proper Weltronic control panel. Correlated design of the complete range of weld and sequence timers incorporating a universal cabinet-and-power supply unit and a series of control panels that can be interchanged without the use of tools or rewiring, permits the welder to be immediately available for any type of operation within its capacity.

High dependability and low maintenance is provided by exclusive Weltronic timing circuits using fewer, less costly tubes and the power supply unit that operates on all widely used service voltages. Timing adjustments are electronically precise, accurately calibrated and protected by a removable, tamperproof cover.

Ask for Bulletin No. WTT-44.



Weltronic COMPANY
DETROIT 19, MICH.

and Steel Industrial Research Council, Vice-President of the Iron & Steel Institute, as well as a member of innumerable Joint Committees and Subcommittees of the British Iron & Steel Federation and the Iron & Steel Institute, being actually Chairman of the following: Heterogeneity of Steel Ingots Committee, Corrosion Committee, Oxygen Subcommittee (now Subcommittee on Gaseous and Nonmetallic Inclusions), Alloy Steels Research Committee and Physical Chemistry of Steelmaking. He was one of the founder members and a member of Council of the new British Iron & Steel Research Association which is to undertake the reorganization of cooperative research in the iron and steel industry. He was a member of Council and of the Research Council of the Institute of Welding and Chairman of the Weldability of Ferrous Metals Committee as well as of the Committee on Physical Metallurgy of Alloy Steel Welding.

GEORGE L. WILEY JOINS BIG THREE WELDING EQUIPMENT COMPANY

George L. Wiley, trail-blazing pioneer in the art of arc welding, has joined the Big Three Welding Equipment Co. at Houston, Tex., as welding consultant, it is announced.

The company with offices also at Fort Worth, El Paso, Orange and San Antonio, is the Texas distributor for The Lincoln Electric Co., Cleveland, Ohio.

Better known in the industry as "Duke," Mr. Wiley has been promoting the use of electric arc welding for the past 26 yr. He was the founder of the first Fusion Forum, has held committee chairmanships in both the AMERICAN WELDING SOCIETY and the American Society for Metals and has addressed many societies, universities and other groups on welding. He was one of the first to undertake the arc welding of oil storage tanks and welded steel construction of buildings.

George L. Wiley

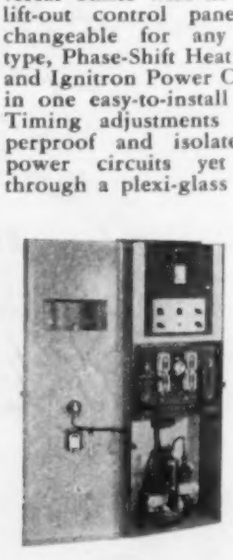
electronic Weltronic bulletins

SIMPLIFIES POST-WELD HEAT CONTROL

Eliminating the necessity for synchronous controls for post-heat treatment of welds, the new Weltronic Model 49 Combination Timer-Contactor-Heat Control can be adapted for full electronic control of such post-weld heat treatment. Use of a simple exclusive interlocking circuit requiring no external wiring changes makes such control available for the first time at minimum investment and maintenance costs.

Adaptable to virtually any manual, motor or air operated resistance welder, the simplified wide range control unit extends the capacity of the machine to meet the requirements of most welding process refinements.

The compact wall, floor or machine mounted unit incorporates the Weltronic Universal Timer with its plug-in, lift-out control panel interchangeable for any NEMA type, Phase-Shift Heat Control and Ignitron Power Contactor in one easy-to-install cabinet. Timing adjustments are tamperproof and isolated from power circuits yet visable through a plexi-glass panel.



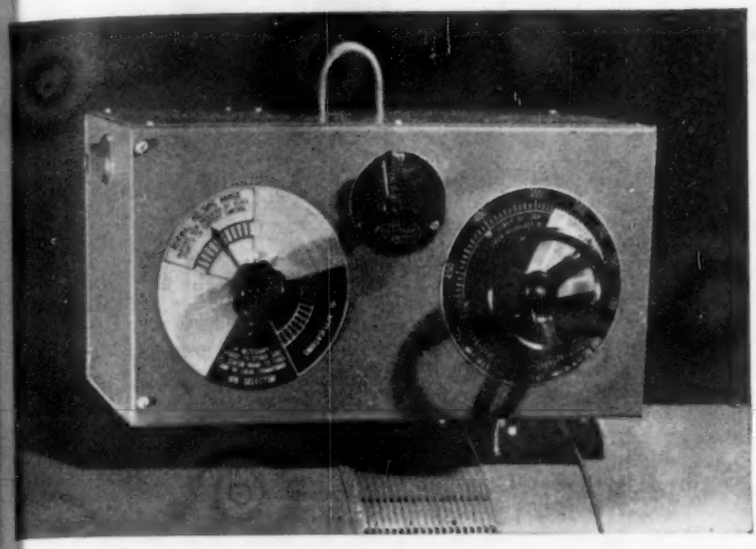
Ask for bulletin No. 49

Weltronic COMPANY
DETROIT 19, MICH.

"SITTING TIGHT," *he says*

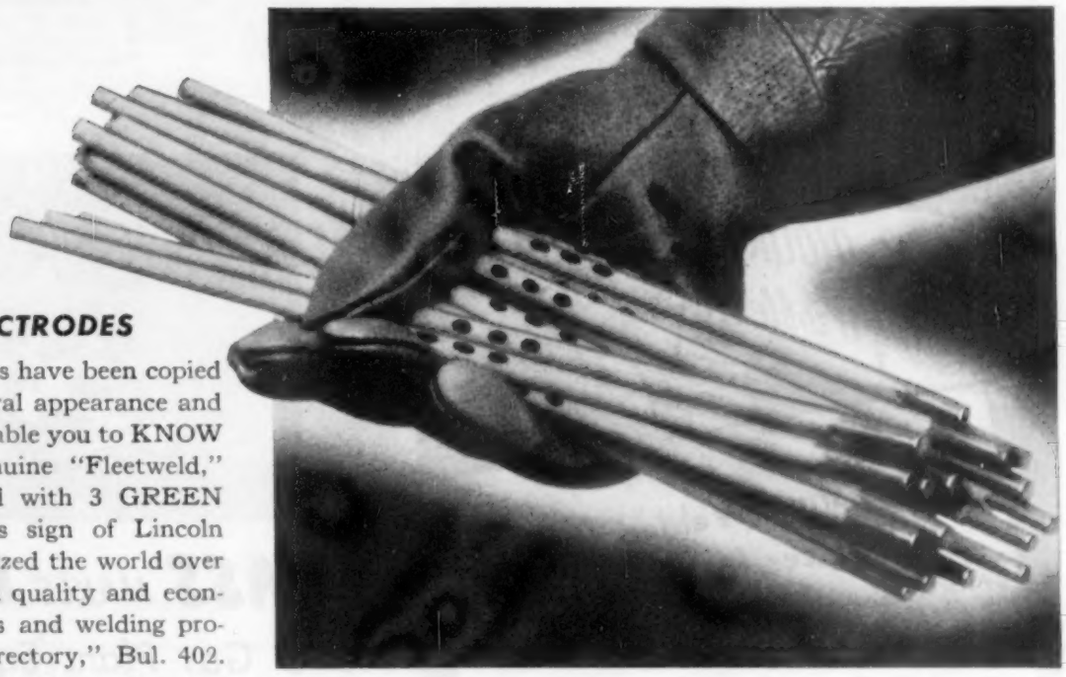
Look, Francisco . . . here is the wherewithal to step out in front with Arc Welding:

THE TOOLS FOR NON-STANDPATTERS



"SHIELD-ARC" WELDER

The "Job Selector" of the Lincoln "Shield-Arc" Welder permits selection of the TYPE of welding arc . . . a predetermined welding characteristic . . . to match the job. Its Current Control provides any desired amperage over a wide range. Both selectors are Self-Indicating for KNOWN results . . . unmatched speed, ease and economy of welding. The "Shield-Arc" is recognized the world over for its superiority 32 ways . . . described fully in Bul. 412.



"FLEETWELD" ELECTRODES

These world favorites have been copied extensively as to general appearance and color of coating. To enable you to KNOW that you get the genuine "Fleetweld," they now are marked with 3 GREEN DOTS. Look for this sign of Lincoln Electrodes . . . recognized the world over for their superiority in quality and economy. Complete details and welding procedures in the "Weldirectory," Bul. 402.

THE LINCOLN ELECTRIC COMPANY • CLEVELAND 1, OHIO

America's greatest natural **recourse**

ARC WELDING

X-RAY INSPECTS CRYSTAL HOLDERS

Fern Henniessy inserts a trayful of quartz crystal holders into the X-ray chamber of a NORELCO Searchray 150 unit at the Dobbs Ferry, N. Y., plan of North American Philips Co., Inc. These frequency control units are vital to the Armed Forces, and this quick X-ray check gives positive assurance that all holder connections are properly soldered.

The inspection is performed quickly, safely and inexpensively, using factory personnel. One tray (96 holders) per minute can be put through the machine and radiographic cost, including film processing, is less than 1¢ per crystal holder. Lead numerals are radiographed with each tray of crystal units, thereby identifying each batch permanently on the film.

BARR PROMOTED

Dr. W. M. Barr, chemical and metallurgical engineer of the Union Pacific Railroad, has been promoted to the post of research and standards consultant for the road, President W. M. Jeffers, of the system, has announced.

The change is effective Dec. 1st, Jeffers said.

A graduate of the University of Iowa, Grinnell College and the University of Pennsylvania, Dr. Barr has been in charge of laboratories, water supply, inspection, tests of materials and specifications of materials for the Union Pacific.

He has done outstanding work in the improvement and handling of water supplies for locomotives and the development of alloy-steel forgings for railway service, including work on high-speed lightweight trains.

Dr. Barr has served as president of the American Society for Testing Materials. He has represented the Union Pacific in the Society for 24 yr., was a member of the executive committee 1934–36 and was vice-president of the Society the next 2 yr., taking office as president June 28, 1940, for a 1-yr. term. He is a member of the AMERICAN WELDING SOCIETY.

Annual Meeting Papers

Suggestions for authors of Annual Meeting Papers to be presented at the Annual Meeting of the Society in October should be sent promptly to W. Spraragen, Sec. Program Committee, A.W.S., 33 W. 39th St., New York, N. Y.

Is this YOUR Cleaning Problem?
Preparing Welded Steel Surfaces for Painting
After resistance, gas or arc welding of steel surfaces, a prime requisite for effective paint adhesion is a clean, GREASE-FREE conditioned surface.
Various specialized Oakite acid and alkaline type materials are available for this essential surface preparation work. ALL provide the CLEAN surface that assures firm, tenacious grippage of paint or similar organic finishes.
If you are experiencing trouble on this type of work, let us help you correct it. Oakite Technical Service is FREE for the asking.
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Technical Service Representatives Conveniently Located in All Principal Cities of the United States and Canada
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Time Stands for Victory
CLEANING
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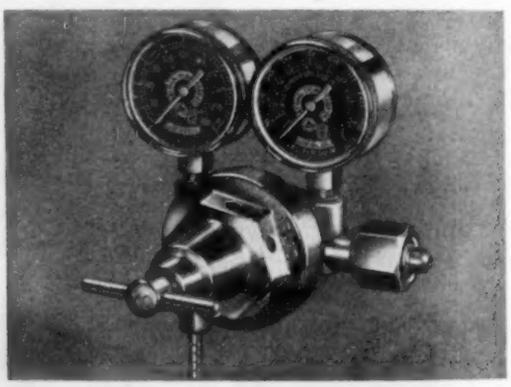

BRASS MAKES BULLETS

REGO Gas Plant Equipment to be safe, must be made of brass and other critical metals. Conserve your equipment. You may not get more.

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The BASTIAN-BLESSING Co.
4241 W. PETERSON AVE. CHICAGO
Pioneers and Manufacturers of Precision Equipment for Using and Controlling High Pressure Gases

SMITHway CERTIFIED ELECTRODES...made by welders...for welders

SIGNAL CORPS PHOTO

NINE LST CONTRACTORS • ALL USED SMITHway ELECTRODES

WHEN nine big Midwest contractors tackled the gigantic landing-ships production program, there was no guesswork. All nine, of their own accord, chose SMITHway Certified Electrodes . . . developed and proved in the huge A. O. Smith plants, where millions of SMITHway Electrodes are used in welding more than 50,000 tons of steel products a month. No other electrodes offer such outstanding performance proof, over a period of many years of mass production.

WRITE FOR CATALOG!

New steels, involving new welding problems, are finding broader fields of application where strength with light weight is required. Be prepared to make the most of welding as a production tool on a thoroughly scientific basis. SMITHway Certified Electrodes provide a variety of accurately controlled analyses for dependable results — proved so, in our own welding shops where many complex alloys are daily being welded in production.

Have You Bought That Extra War Bond This Month?

Mild Steel . . . High Tensile . . . and Stainless Steel
WELDING ELECTRODES

SMITHway A. C. Welding Machine saves power; eliminates arc blow.

SMITHway Welding Monitor trains welders faster.

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In Canada—JOHN INGLIS CO., LIMITED

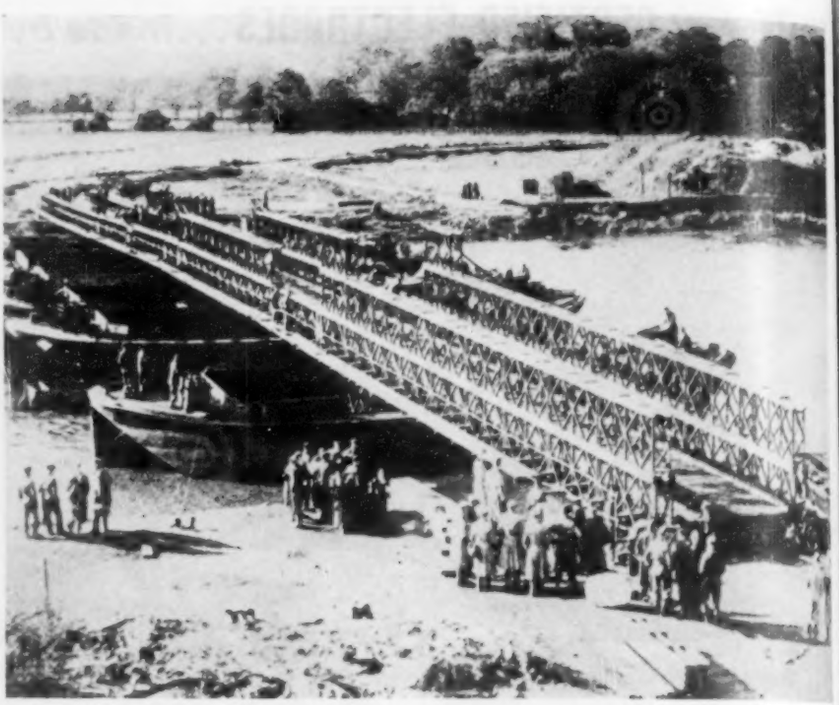
PORTABLE BAILEY BRIDGES BEING FABRICATED IN U. S.

With the relaxing of strict military censorship, it can now be revealed that the famous Bailey Bridge originally designed in England is now being prefabricated by several manufacturers in the United States.

Credited by Field Marshall Sir Bernard Montgomery with much of the swiftness of his successes in Tunisia, Sicily and Italy, the Bailey Bridge has become standard equipment for the United States Army, as the ease and speed with which it can be assembled in the field cut delays in the movement of troops and equipment in the wake of enemy demolition.

The units consist of adjustable struts appearing as a network in the photo. They are approximately 34 in. in length, and are arc welded on four sides from $^{5}/_{16}$ in. and $^{1}/_{4}$ in. plate, "boxed," forming a $3^{1}/_{16}$-in. square with clevis bar in each end, and perforated with 60 pinholes for adjustment.

In the foreground of the photo, which shows the Bridge being used in Italy, may be seen the transom floor beams fabricated by arc welding H. T. Steel. They are 18 ft. long and 38 of them are used in each bridge section or span.



U. S. Engineers Corp. Photo
Courtesy The Hobart Brothers Co., Troy, Ohio.

STEELCRAFT

"Steelcraft," a 26-ft. all-steel cruiser which may typify the pleasure craft of the future, has been accounced by Jack Churchward of Churchward & Co., West Haven, Conn.

"Steelcraft," says Mr. Churchward, "is the outgrowth of a 12-yr. development we have conducted in welded steel construction for small craft. It is the result of our aim to give the public at a reasonable price the many advantages of steel construction. The technological advances during the past few years of war construction have paved the way. Now we believe we have the answer in 'Steelcraft' for the boat enthusiast of moderate means who has wanted a cruiser, speedy, streamlined, easy-to-handle, inexpensive to buy and inexpensive to maintain. 'Steelcraft' is just that."

Steelcraft

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them ***Unequalled for Quality***

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

Time Counts—
Gas cut and Weld with
Shawinigan Carbide

SHAWINIGAN
SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING, NEW YORK 1, N.Y.

"You Have to

HAND IT TO AO

for a real

WELDER'S GLOVE"

It's Gun-cut (seamless palms) with flat finger seams to prevent chafing. Made of top quality chrome tanned cowhide, it stays pliable, permitting perfect control of rod and torch.

Call the nearest AO Branch Office and have a representative help you choose the proper types of welding gloves and mittens for your particular work.

American Optical

COMPANY

SOUTHBRIDGE, MASSACHUSETTS

The new streamlined cruiser will be produced in three styles—runabout, day cruiser sleeping two, and sedan cruiser sleeping four. Normally equipped with an 85-hp. motor giving a speed of 20 mph., the cruiser may also be had with two motors and twin screws, increasing the speed to 35–40 mph.

The hull of "Steelcraft" is fabricated from only seven pieces of steel, welded and completely stress relieved. Two pieces form the bottom (v-type), two pieces the sides, one each for the deck, the chine and the transom. Construction has the strength of 4 in. of oak and yet is lighter than wood. Interior parts, being of steel, are relatively small, permitting about 15% more usable space than wood hulls of the same size.

All underwater fittings are of steel with the exception of the bronze shaft and propeller. Electrolysis is avoided by engineered compensation.

Because of her rugged construction "Steelcraft" is an ideal boat for the novice. Her v-bottom and wide beam make her steady and dry.

R. P. I. PRESIDENT

Livingston W. Houston has been elected president of Rensselaer Polytechnic Institute, Troy, N. Y., the country's oldest college of engineering and science. A trustee of R.P.I. for nearly 20 years, he has been active in its management for more than 10 years as secretary, treasurer and executive vice-president. He was formerly president of the Ludlow Valve Manufacturing Co. of Troy, and is now a director and chairman of its board. He was graduated at R.P.I. as a mechanical engineer in 1913, and is a member of the American Society of Mechanical Engineers.

OUTDOOR SPOT WELDING

Already extensively used in inside manufacturing operations, spot welding has now moved out of doors at The Glenn L. Martin Co., Baltimore, Md., where special portable equipment was recently used on the flight line to attach an added 0.030 stainless steel part to the baffle of the PBM Mariner exhaust system.

A special portable spot welder, consisting of a control and transformer unit and a hydraulically operated welding gun was assembled by Martin welding engineers for this job. The control and transformer unit was then positioned over the airplane in which the welds were to be performed by a traveler crane, with the gun in turn

Fig. 1—Spot Welding Goes Outdoors

An added part is attached to the PBM Mariner exhaust system baffle on the flight line at The Glenn L. Martin Co., Baltimore, Md., with a special portable spot welder assembled by Martin welding engineers from standard equipment.

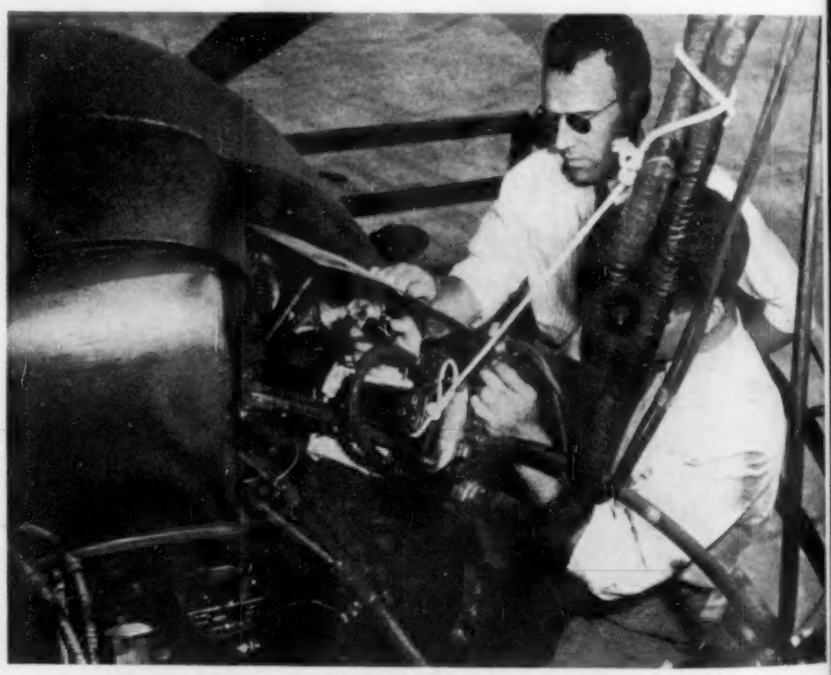
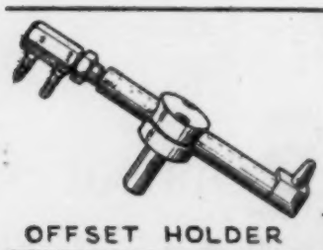


Fig. 2—Close-up of Outdoor Spot Welding

Despite the difficulties involved, welds produced were of production quality



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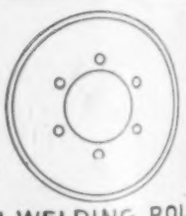
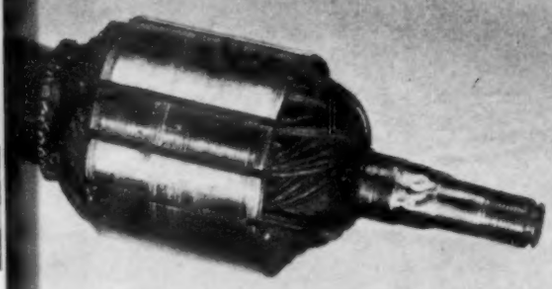


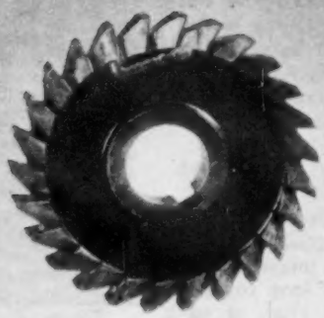
OFFSET HOLDER

THE ELECTROLOY CO. INC. 1600 SEAVIEW AVE. BRIDGEPORT, CONN. WELDING ROLL

TRESSES AND OVERHEATING



Worm motor armature shaft resurfaced by Eutectic Low Temperature Welding completely avoiding warping of shaft and preventing destruction of windings by excessive heat.



Heat-treated high-speed steel cutter would be softened by high heat of conventional welding, brazing and soldering methods. Repair at Eutectic low temperatures eliminates need for final rehardening.

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suspended from the transformer and control unit. Power was supplied by a special 500-ft. cable feed, with an additional 8-ft. line running from the transformer and control to the welding gun. Since water cooling was not necessary, welds per minute were reasonably low, vastly simplifying the operation.

Although this is the first known instance of the outdoor use of spot-welding equipment, welds produced were of production quality.

The Saga of Welded Ships

By A. F. Davis*

WHEN historians record the full story of World War II, one of the most stirring chapters will undoubtedly deal with the amazing ability of welded ships to withstand the terrific impacts, explosions and frequent fire damage to which they were subjected by enemy action during the crucial years of 1942 and 1943.

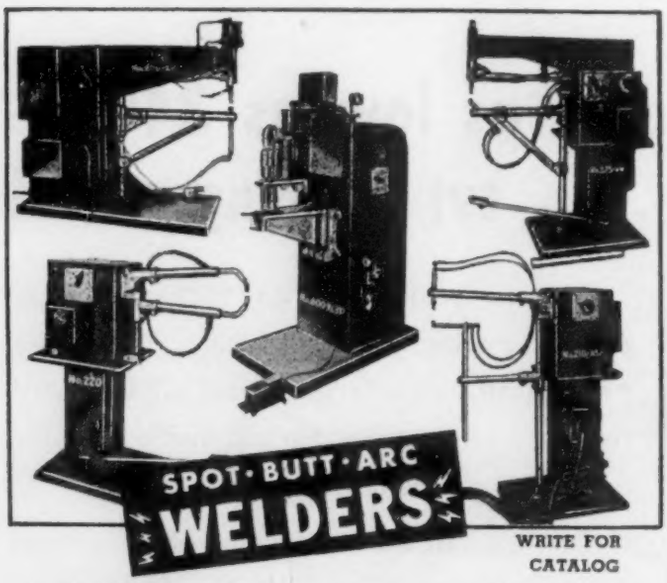
Besides actual combat service, many of these vessels, under emergency shipping conditions, had to hold up under the severe stresses and strains of long voyages through heavy seas in all kinds of adverse weather conditions.

Although a number of gallant seamen were lost during the height of Axis efforts to cut our vital supply lines, prominent naval authorities agree that the saving of an untold number of lives was undoubtedly due to the sound principles of ship construction made possible by welded design.

Fig. 1—The "Anne Hutchinson," All-Welded Liberty Ship Still Afloat After Being Torpedoed Off South Africa. (Official U. S. Navy Photo)

Some of the most dramatic stories in marine history have come from the logs of the famous Liberty-type ships. Although many of these sturdy vessels have been blasted by torpedoes, bombed from the air and raked with enemy shell-fire, nearly all of them are still in active duty.

* Vice-President, The Lincoln Electric Co., Cleveland, Ohio.



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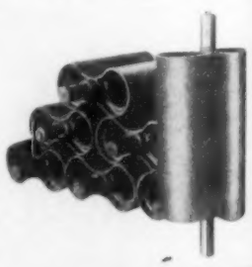

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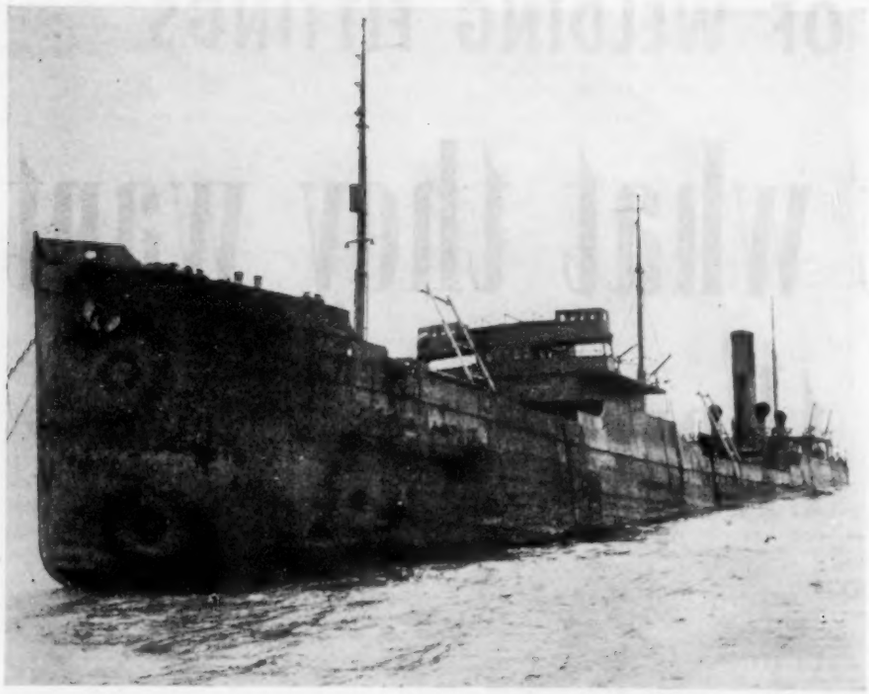

Fig. 2—Torpedoed Merchant Tanker Kept Afloat by Water-Tight Compartment and Sound Construction. (Official U. S. Navy Photo)

In evaluating these welded ships against the outmoded vessels of the riveted type, Admiral Emory S. Land, Chairman of the Maritime Commission, had this to say: "Every time a riveted ship goes into dock, you have a lot of repairs to do. You do not have them in welded ships. You do not have leakages. You do not have openings in your hulls with dozens and dozens of leaks, nor do you have to redrive rivets. Even if we have these fractured plates, it is not a handful compared with the casualties that go in riveted ships every time they go in for voyage repairs, something that everybody else seems to have forgotten.

"On combat damage, comparing Liberty ships and others, everything is all in favor of the Liberty ships. A lot of these have broken into sections due to combat damage; in Liberty ships, the percentage is entirely in favor of the Liberty because the riveted ships are apt to go to the bottom when they are bombed or mined or torpedoed. It is truly remarkable the salvage we have obtained from these Liberty ships in combat damage. Never mind about the fractures or cracks—they get into port."

The *Patrick Henry*, first Liberty ship to go into active service is one of the scores of vessels of this type which have substantiated Admiral Land's remarks.

Launched in September 1941 the *Patrick Henry* was subjected to numerous bombings and torpedo attacks on such dangerous routes as those to Murmansk and Archangel, and to Capetown and Suez. After 2 yr. of severe service during which the vessel traveled some 80,000 miles and moved more than 76,000 tons of supplies to Allied war fronts, an inspection of the *Patrick Henry* showed her to be in first-class condition and prompted the War Shipping Administration to hail her performance as "even better than anticipated."

One of several Liberty ships that were torpedoed but refused to sink was the *Anne Hutchinson*. Describing the incident in a production communique to the builders, Oregon Shipbuilding Corp., Admiral Land said, "To you who built the SS *Anne Hutchinson* goes credit for having built a sturdy Liberty ship. She took two

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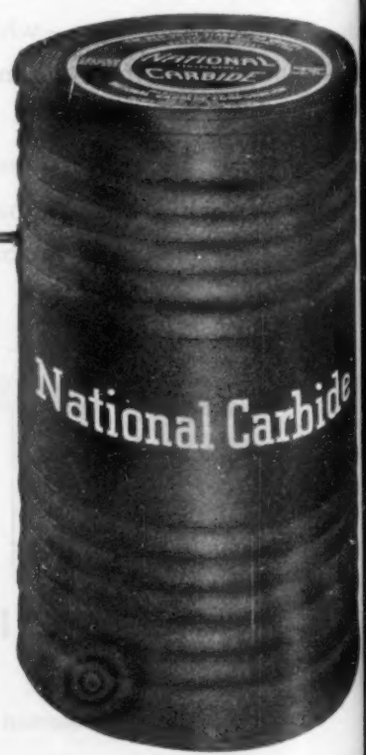

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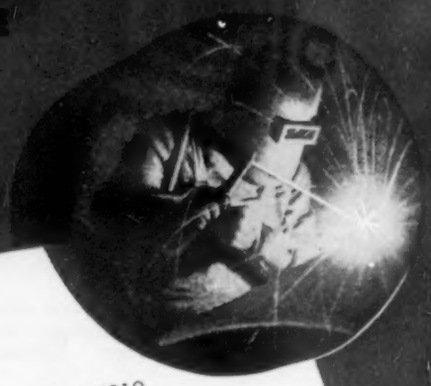

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"	8, General Purpose, Poor Fit-up	AWS E-6012
"	13, General Purpose, Light Gauge	AWS E-6013
"	20, Horizontal Fillets	AWS E-6020
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"	18-12(2-3% Mo)	Type 317
"	18-12(3-4% Mo)	
"	19-9, For Welding air-hardening steels	Type 307
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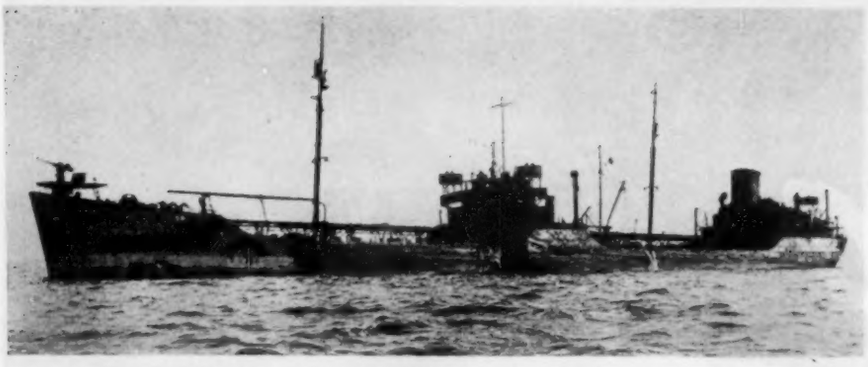


Fig. 3—The Gaping Hole Shown in This View of an 18,000-Ton Tanker Failed to Send Her to the Bottom. Sturdy Welded Design Prevented Critical Damage Despite Loss of Two of the Ship's Crew. (Official U. S. Navy Photo)

torpedoes in her stride and refused to sink. It was on her return trip when the first torpedo struck in number four cargo hold. The explosion almost lifted the ship out of the water, it severed the line shaft and practically tore out the ship's bottom. The vessel broke in half and it was only after being buffeted by storms that the after part sank. The bulkhead of the engine held and the forward part of the vessel remained afloat. Later the second torpedo struck in the starboard engine room in the way of the boiler. Three seamen were killed. This explosion completely destroyed the starboard boiler and shifted the main engine from its foundation 10 ft. to port. Still your vessel would not go down, she remained in an upright position and was towed into port. The survivors said the buoyancy of the vessel after being sliced in two parts was amazing. All of you who worked on this ship can feel justly proud of her. She proved she could take it. Keep building them like the *Anne Hutchinson*."

Included in the long list of all-welded oil tank ships with notable performance records was the motorship *Pennsylvania Sun* which has piled up a total of 506,000 miles in voyages. This vessel was torpedoed in 1942 suffering extensive damage to the hull, the superstructure being entirely gutted by fire.

The Sun Oil Co., operators of the ship, told of this action in a recent letter which stated, "The vessel was torpedoed at the midship house on the port side and the explosion tore away the side shell plating, one wing bulkhead and pierced the other wing bulkhead and opened approximately seven of the cargo tanks to the sea. However, when the fire on the vessel was put out by the ship's officers and a salvage crew, the crew reboarded and after temporary repairs were made which permitted the ship to proceed under its own power, the vessel was placed in dry dock at Chester, Pa., for the execution of damage repairs. It was noteworthy in most cases

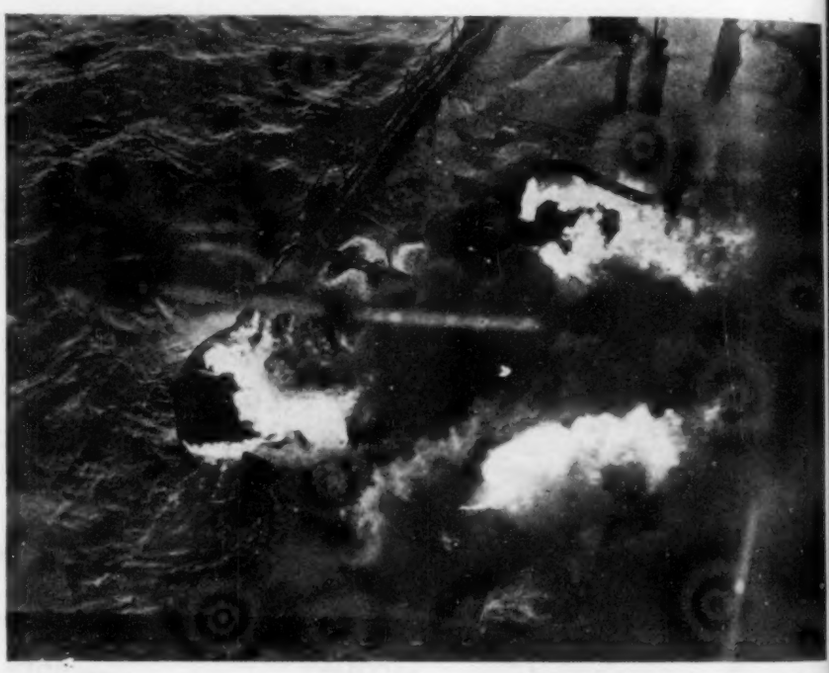


Fig. 4—Flames Rage Around the Big Hole Torn Amidships on the Port Side of This Merchant Ship Which Was Later Repaired Sufficiently to Proceed Under Her Own Power to Safe Waters. (Official U. S. Navy Photo)

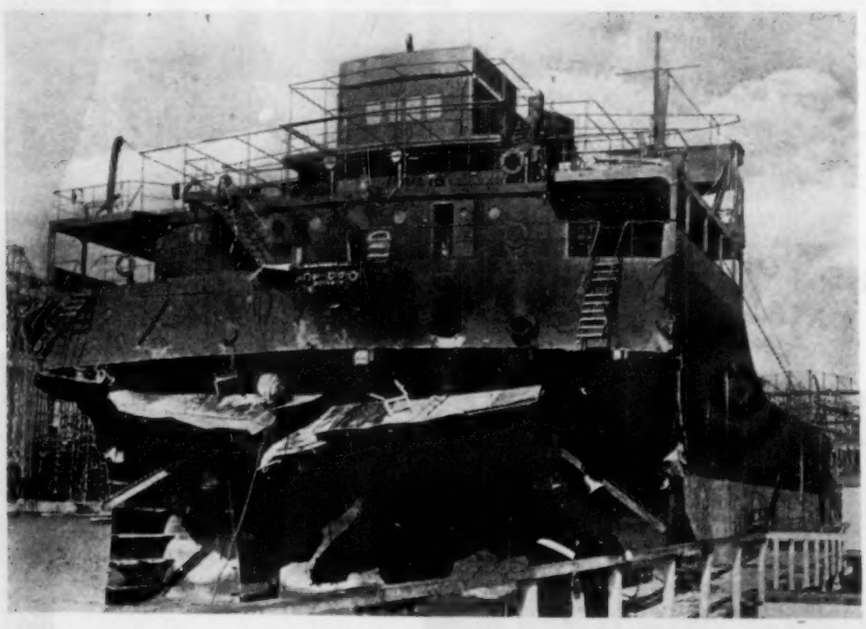


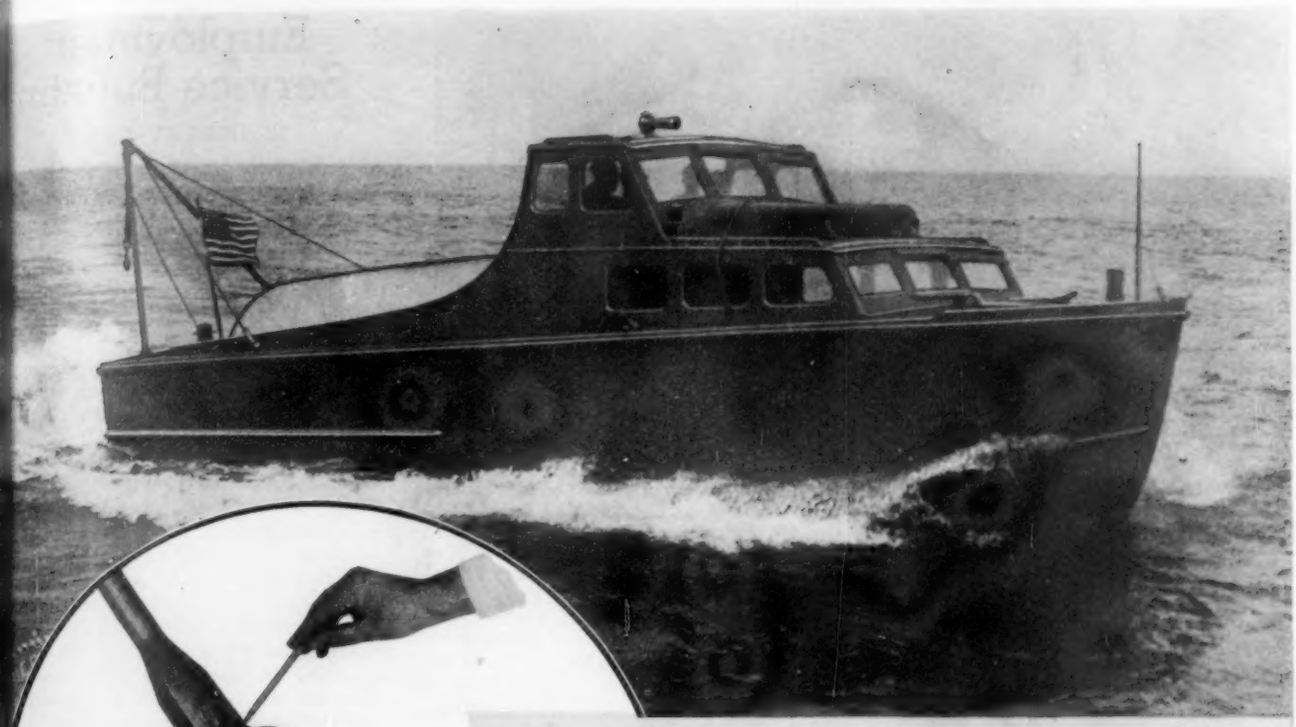
Fig. 5—When Stern of the "E. H. Blum" Was Damaged, It Was Cut Away and Forward Section Shown Here Was Towed to East Coast Port for Repairs. Salvage Made Possible by Rigid Welded Construction. (Official U. S. Navy Photo)

plates would tear in half or would depart from a welded joint to tear through the middle of the plate, the welds apparently showing up stronger than the steel itself in the plate."

The reliability of welded hulls is further emphasized in another report from the War Shipping Administration on the *Robert E. Peary* which sustained major damage on two occasions.

The report, typical of many similar instances proving the ruggedness of welded construction, states, "In May 1943 en-route to the United Kingdom water was found in No. 3 compartment as a result of fractured shell plates. Damage was believed to be the result of depth charges, but this information was not confirmed. The vessel was drydocked and repaired in the United Kingdom. In December of 1943 the vessel was involved in a collision outside of Halifax, N. S. She was returned to Halifax for drydocking and repairs. Exclusive of her present voyage, this vessel has traveled approximately 42,246 miles."

Ships such as these which exemplify the value of welded design and illustrate what an important part modern welding pro-



This manganese bronze rudder blade and shaft (cast elsewhere) revealed a defect when machined. The $70 casting was saved from the scrap pile by welding with Ampco-Trode 10.

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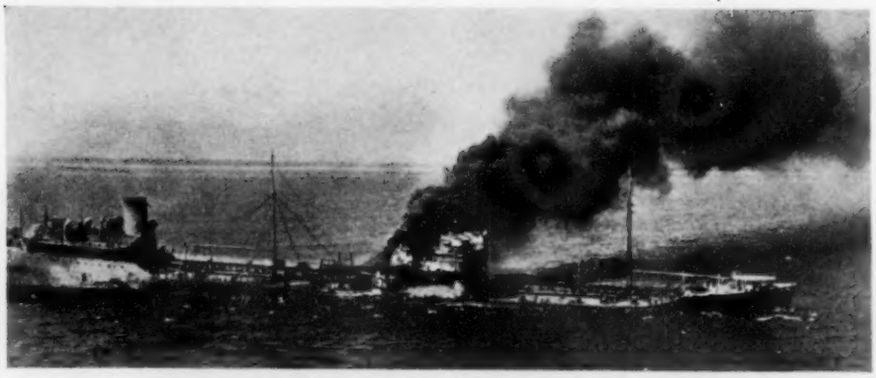

Fig. 6—Dense Column of Black Smoke Shows Where Axis Blow Struck. Despite Combat Damage, Ship Was Salvaged for Future Deliveries of Vital Cargoes. (Official U. S. Navy Photo)

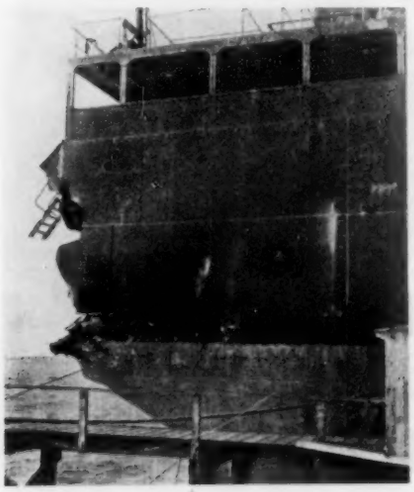

Fig. 7—Close-up of a Torpedoed Liberty Ship After Stern Section Had Been Damaged by Enemy Action at Sea. Photo Shows Forward Part of Ship After It Was Towed to Port. (Official U. S. Navy Photo)

esses are playing in helping achieve final victory, were produced at the rate of more than 2158 hulls in the relatively short period of about 40 mo.

It was this record which led the special Committee Investigating the National Defense Program to report that, "The most material departure from the method of construction of the original ship was in the use of electric welding instead of riveting. The adoption of assembly line methods and extensive prefabricating of parts also made possible the construction of a greater number of ships than had ever before been contemplated.

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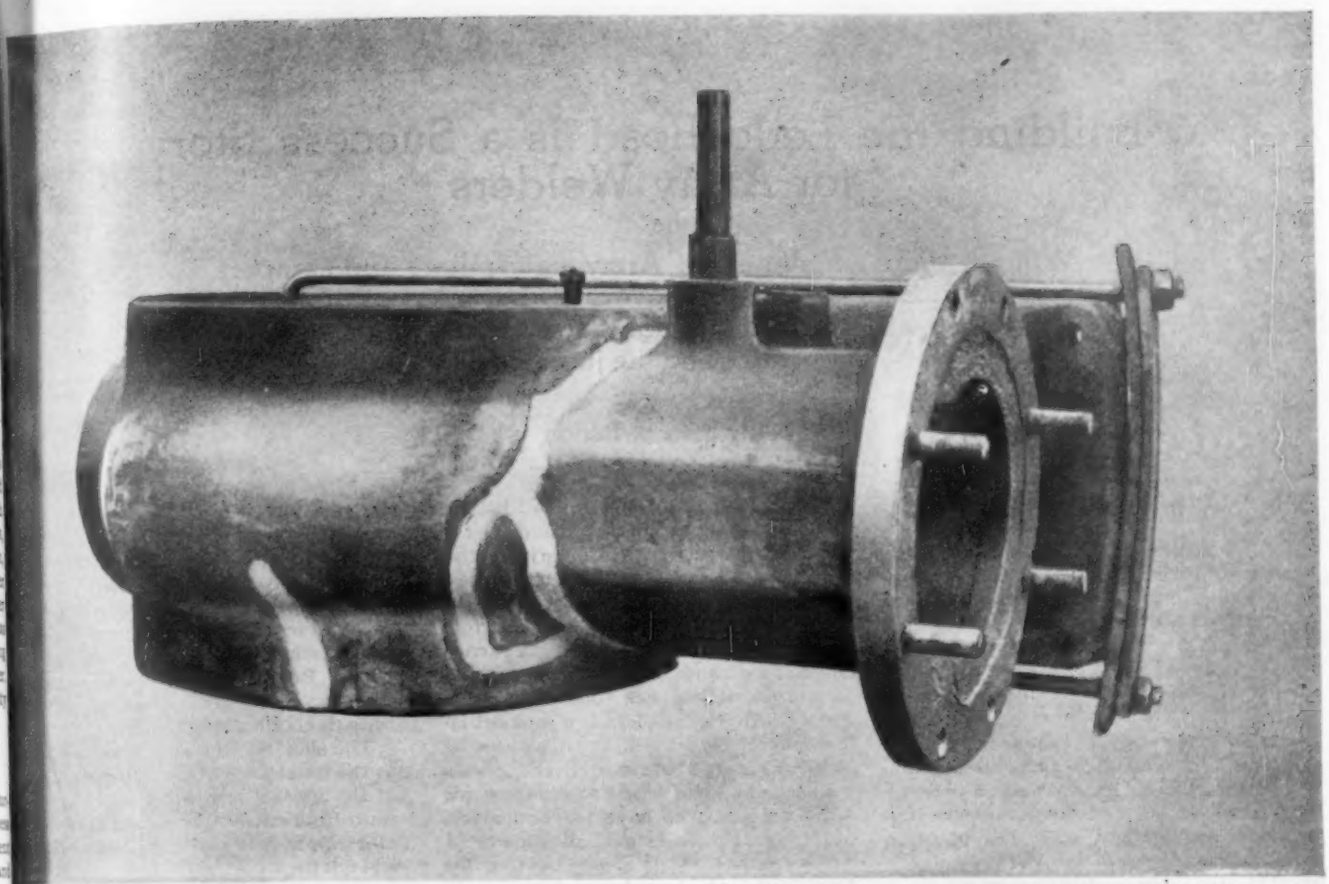

10 hours of Tobin Bronze Welding Restores Oil Engine to Service

CRACKS in the crank case of this crude-oil engine spread, in spite of the use of clamps, until they practically encircled the casting.

Replacement would have been costly and, even more important, would have involved downtime running into weeks or perhaps months. Instead, repair welding with Tobin Bronze* Rod was undertaken. In ten hours the casting was repaired, ready for reassembly and the resumption of its important function.

More and more, as such instances of time and money saving pile up the evidence, industries of all types and in all parts of the country are accepting the slogan "Don't scrap it...bronze-weld it!" Before you replace machinery that seems hopelessly damaged, consider repair welding with Tobin* Bronze or Anaconda* "997" Low Fuming Rods. 45107

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Building the Ledo Road Is a Success Story for Army Welders*

Without their maintenance, Army caterpillars and scrapers and bulldozers and earth-movers and trucks would never have been able to win the fight against the mud and the rains and the jungle

By Fred B. Barton†

YOU'LL be hearing more, but never enough, about the Army engineers and their fight against the jungle over in Burma. Whether the Ledo Road brings entry into China for enough supplies to win the war against the Japs or whether that war must be won chiefly by the Navy and the task forces breaking through from the Pacific, this much is certain and clear:

The Ledo Road is a monument to American engineering and American courage. To have built it at any time would be an achievement. To have built it under the heat of summer and the downpours of two monsoon seasons, with Jap planes overhead raising their mischief, is unbelievable—the more so after you see it.

I came down from China by C-47 and landed in Assam (northern India) on a Saturday night. Friends prevailed on me to spend a few days seeing the Ledo Road in person. So on Monday I rode four or five hours on a self-conscious and noisy little railroad now operated jointly by the Indians and the American GI's. That put me in the town of Ledo.

Four months of China during the summer had accustomed me to mud, but there is no mud like Ledo. Burma has the greatest rainfall in the world, in some spots as much as 300 inches—25 FEET—of rain dropping within a year, and most of it during four hot, sticky, muddy months. Mud causes accidents, washouts, endless delays in any corner of the war. Yet the Ledo Road has been pushed through, foot by foot, despite cave-ins that have carried huge "cats" and trucks to destruction; despite mud that has sometimes made Army 6 x 6's* as helpless as a rowboat on the Sahara. It's a job any man can be proud of having a part in.

The Ledo Road is a success story for Army doctors, who have fought malaria and tropical diseases and all manner of skin infections. It is a success story for Army cooks, who have kept up the morale of our Army men in their lonely jungle camps where there was little do to and no safe place to do it. It is a success story for American truckers and caterpillar operators, both negro and white; and of diggers, big scoop operators, and with them, repairmen of all kinds.

But let's tell the story here briefly in terms of the Army welders. Step into the jungle workshops of the (censored) Heavy Shop Engineers, established as a Fifth Echelon shop, which means they have personnel and the machine tools to or rebuild almost an entire bulldozer you just give them the steel. Jean Walker is away at the time, so talk to First Lieutenant Edwin J.

"Our shop covers maintenance on entire Road," says Andell "Whenever any crew gets a tit the wringer they holler for us."

The shop may be moved forward as the Road moves on to join the of the Burma Road now reaching ward from out of China. Right now at a supply center which the Press will not permit to be named: a small mese settlement with some Army barracks and shops erected tin roofing and random building and stuck away in the ever-present The area where the shops are located not even a wide-place-in-the-road when Army chiefs brought Walker and out here, a short year ago. It was wilderness, "You asked to have your placed far enough ahead of the you'd always be in the center of said the Colonel. "Here now is your What are you waiting for?"

They're fairly comfortable now, to American ingenuity in rigging camp kitchen that furnishes running

*Written in Burma for The Lincoln Electric Co.
† War correspondent.

* In case you don't know, a 6 x 6 is a huge GMC truck with two rear axles and two sets of rear wheels, and with power that can be applied to front wheels and all rear wheels. Hence 6 wheels, 6 drives or, in Army shorthand, six-by-six.

Fig. 1—A Portion of a Convoy on the Ledo Road. Convoys Contain as Many as 70 Trucks

Fig. 2—American Aviation Engineers Repairing a Section of the Ledo Road After Heavy Monsoon Rains

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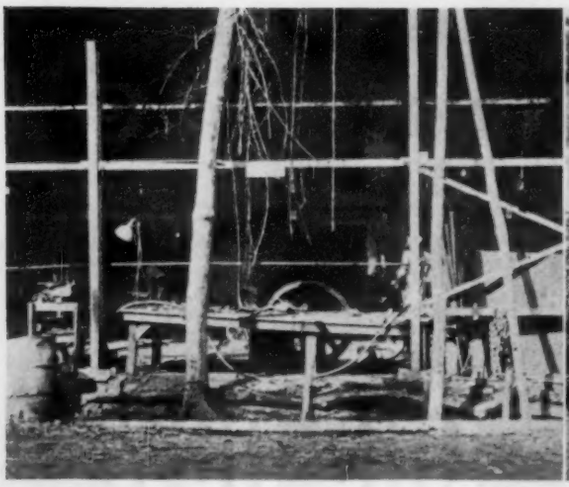

Fig. 3—The Welding Repair Shop. Three Welding Booths Are in the Rear. Jobs Overflow the Floor. When the Time Comes to Move Closer to the New and Tougher Road Construction Jobs—Shops Are Disassembled and Loaded on Trucks Equipped for Gas and Arc Welding

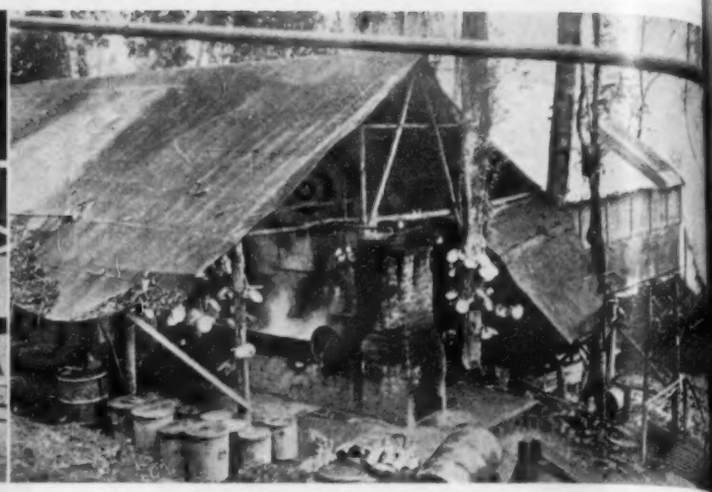

Fig. 4—Kitchen of the Messhall. Despite Heavy Rains Water Is Brought by Truck and Pumped in the Storage Tank Made by Welding Three 6 ft Culverts Together

water (they had to make holes in pipes with a cutting torch and weld their T-joints not having taps-and-dies and plumbers' equipment). They eat well too, even though the bulk of their food is made up of the Army's canned C-ration. But they all remember the times when food arrived by parachute and was limited in quantity and in variety. And Lieutenant Andell still remembers the times he and Captain Walker sludged through the mud for miles, with musette bags strapped to their shoulders, carrying mail for their men from a mail truck stuck in oceans of mud, a dozen miles back along the combat trail. They were willing to sacrifice personal comfort to bring the mail through, of course, because nothing puts heart in GI-Joes as much as news from home.

Part of this outfit's work has been to help repair bridges, some of them bombed out by the Japs, others carried out by the streams—rivers here sometimes rise 9 feet in two hours; the rainfall is often 10 inches just overnight, and because the ground absorbs little moisture everything pours into the rivers in no time at all. The road engineers do the actual bridge building, but this heavy repair shop helps make the bolts, plates and fish plates. That is a story by itself: patching and improvising, using scrap metal of any possible kind to hold the girders together and let the trucks go through. (For military reasons nothing more than this can be said about bridges along the Ledo Road at this time.)

But most of this shop's activities have dealt with keeping tractors and caterpillars and road scrapers in service. Take the time a huge Lorain 2-yard bucket shovel was down with worn worm-and-gears and teeth worn down to the nubs. The thing was the biggest single piece of equipment on the Road. It couldn't be replaced. Spare parts were 15,000 miles away. The job had to be boy-scouted back together again somehow.

Such jobs as these make Lieutenant Andell say "Welding is just one of our activities, but if it weren't for the welders there wouldn't be any Road."

They built up the shattered teeth with arc welding and felt themselves lucky to have good welding rods. The cracked and worn gears they gouged out with a power drill and reinforced with welds. That took care of the emergency.

For a time they had a steady stream of rush jobs on $1^1/_2$- and 1-yard shovels. These breakdown jobs had a habit of popping in on them at all hours of the day or night, so they went to work to build up a reservoir of spare parts. Sometimes they could salvage teeth from a machine that had toppled down a 700-foot fill and been smashed. Sometimes they repaired parts that had been junked, or built new parts from scratch. But once they got a few parts ahead the work became easier. With their circulating library, so to speak, containing extra teeth they can service your Lorain or Buckeye or Bucyrus-Erie shovel and put it back into use quickly, and then go to work putting a new hard-surface edge on your damaged part. The same goes for cylinder heads, and for track rollers—they wear out badly too in this mud and dust and have to be rebuilt.

In a shop like this you throw the manufacturer's handbook away and do the best you can without spare parts. "Often the only thing we can do is to knock the assembly down and stitch the broken parts together by arc welding," says Lieutenant Andell. "If anything goes wrong we've got to disassemble it with a cutting torch, but even so the machine will have run another night without a breakdown."

Just to show you: The average caterpillar operator likes to make time, but if you push a "cat" over the road for say 100 miles in high gear you burn out the transmission. The manufacturer supplies a safety plate to bolt over the gearshift which seals off high-gear and forces the job to travel at about 1 mile per hour. But anybody can unbolt the plate, so what good is it? Now they *weld* this guard-plate in place, forcing the operator to cover his 100 miles in 100 hours, sleeping either in a trailer or roadside camp or slinging a hammock inside his own machine. This costs him a week's time but it keeps the gears and drive shaft from overheating. Arrived at the destination the "cat" undergoes a little surgery with cutting-torch; but enroute its speed safeguarded and kept well below fi heat by means of welding.

Every GI mechanic in China-Burma-India knows well that his outfit is dependent on the longest supply line in history and that spare parts you can get in a service station back home may be scarce as hen's teeth where he is. The Army doesn't inquire into costs: it merely wants to have the job done quickly and properly and with the men and materials available at the time. So in a heavy repair job like this the extraordinary has a way of becoming the routine and commonplace.

Here's a LeTourneau 12-yard scraper a rubber-tired job: you work those river beds, getting out gravel. The grit wears out the cutting edge. So you put new ribs by welding.

Some careless operators use their "cats" till they not only wear off the cutting or grading edge but wear into the moldboard. Then the bolts will no longer hold. This shop knows how to flow new metal into the holes by arc welding. (Until a week before my arrival they had no metal-flowing unit. That just came.)

Shovel booms have a way of going over the bank and getting broken and bent. So the shop hunts up scrap channel iron and patches them. It's all a welding job, no bolts whatever.

Similarly, pile-driver leads—where the hammer goes up and down—wear out through heavy work or get damaged by going over the bank. Another patch-and-job for welding, and make it strong and make it smooth!

Along with these road-building jobs there are others, smaller and not so dramatic. Take 5-ton booms, erected on the tail end of trucks and designed to lift 55-gallon drums or hoist the engine out of a "cat" or do any other lifting job. The War Department has issued some, but till lately not enough, so this shop made some of its own. That has saved a lot of enlisted men's backs.

New MUREX WALL CHART

A helpful guide to selecting the right Electrode for the job

This new chart, just off the press, contains a complete list of Murex Electrodes divided into four groups for quick reference; mild steel, special steels, stainless steels and hard surfacing. Electrodes are described according to AWS-ASTM class. Color identification, recommended current strengths, polarity, and physical properties are also given. In addition, there are brief descriptions of the electrodes' general characteristics and applications.

The chart is 24" x 37", printed in four colors.

Copies will be sent free to those who request them on their company letterhead.

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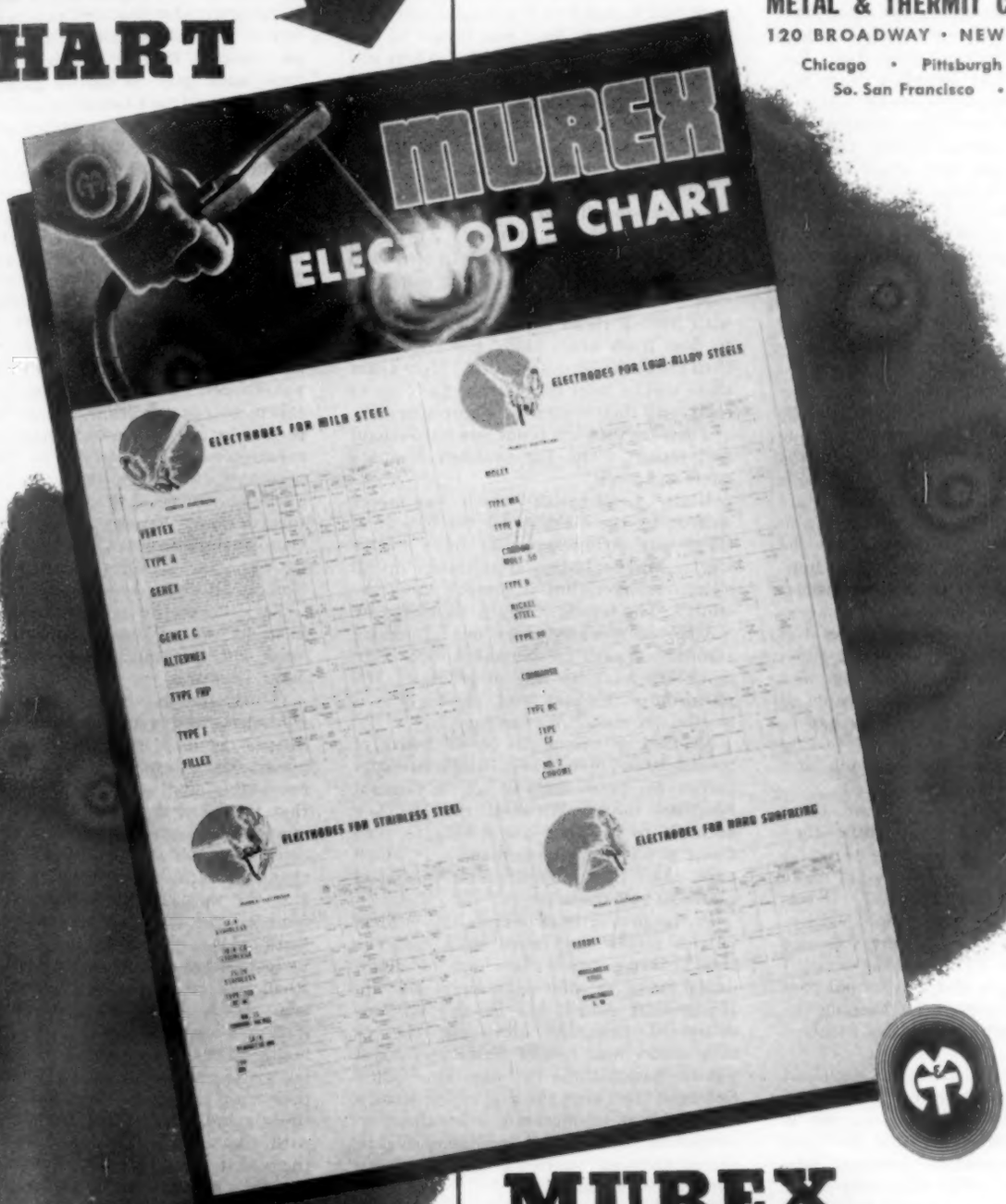

MUREX Electrodes

"Some orders appear small, when you look back through the order book, but were nonetheless important," says Lieutenant Andell. "A unit comes in with a GI stove that is cracked and needs a weld. That broken part affects the comfort of 200 men, so we fix it. Another outfit, further down the Road, asked if we could make them two big cake pans. We did, and flew the pans down to them. Were they happy!

"Water tanks are an item not issued to us, so we take three 6-foot culverts, weld them together and fasten in a bottom, and there's a tank holding 1200 gallons—enough for a fairly sizable outfit.

"We fixed up our own kitchen too by welding," he goes on. "We built a brick chimney and pedestal and put a 50-gallon steel drum over the flames and three other drums, sawed in half lengthwise and welded together at the edges and opened out flat, to heat water. The 50-gallon drum provides a steady supply of boiled water to fill the men's canteens and transfer into the self-cooling canvas Lister bags for drinking. The open half-drums hold hot soapy dishwater at meal time and steaming-hot rinse water for sterilizing the men's mess kits, to cut down dysentery." This outfit also provides hot showers for an hour or two each day, a luxury much appreciated by muscle-weary men. Lieutenant Andell points out that the hot showers cost the Army nothing, being made up out of scrap material and welded on the men's own time.

Then there's a sawmill unit up the Road, lumber of any kind except bamboo bashas being a serious problem here in the jungle. (Some of the Army's mess halls at various road-maintenance points are made of beams and boards salvaged from former Chinese bridges, in use when the Road was just a wagon trail.) This lumber unit is made up of trained woodsmen from Washington and Oregon. Their Sergeant Treat operated his own lumber mill and has come up with some good time-saving ideas for handling teak logs and other jungle timber. But practically all the outfit's sawmills and what-not had to be improvised, much of it by tearing down something from the junk pile and welding it into something new.

As long as they have the time, these Engineers don't care what outfit they work for. Not long back a crew of fighter pilots had an idea they felt would make their pursuit ships more effective. It was a small gadget, and the shop's welders were happy to fix it. (The Press Censor knocked out about 10 lines of the details.) "The pilots were grateful, but for our part we were grateful to them for keeping the Japs away while we work," says Lieutenant Andell briefly.

Looking around, Lieutenant Andell and his crew can say with pride, "There isn't a power shovel on the Road can say it doesn't have teeth." He and his men can point to tremendous overhaul jobs put back into service in incredibly short time: they know in their hearts that when they get back to civilian life there won't be many emergencies they can't find an answer for. And they have begun to find out some of the million uses that welding can be put to.

There is another thing you notice when you visit this shop. That is the spirit of friendliness and efficiency. Military etiquet isn't dispensed with, but it isn't allowed to get in the way. The tragedy of any army is its enlisted men who sometimes know more about a job than do their officers but are prevented or discouraged from making suggestions or attempting anything original. American industry has profited tremendously by coaxing forth the suggestions of its men-in-the-ranks. In this heavy repair shop, however, officers and men work closely together. If a GI welder says "I think we can do it this way," the officer probably says "Go ahead—I'll back you up." The Army has not yet worked out any real merit program—a careless and destructive driver or machine operator is paid just as much as is a careful one—but in a workshop at least you expect to find a measure of efficiency. And also here you find democracy at work without regard to rank or title. It's the sort of thing you hope to find in any American Army workshop, even overseas in foreign Burma under the heat and strain of war.

Surprisingly enough, Ledo Road engineers occasionally do some repair work on boats and outboard motors. There are some swift mountain streams to cross and occasionally to navigate during construction. Propeller blades come into contact with hidden rocks and the welders have to flow fresh brass along the edges and then grind the blades smooth. Here again there will be more to tell when the censors relax with their scissors and blue pencils.

Their big problem is not how to overhaul and repair. The big problem is spare parts and steel.

Under Lend-Lease (which was never written by the GI's, or for the benefit of GI's) our Army overseas buys native steel. Maybe Indian steel stacks up all right on paper, but it doesn't have the stuff. "The tensile strength, measured by S.A.E., is nowhere near our American standards," says Lieutenant Andell. "In fact, they have no way of grading. It's just iron or it's just steel. Some of it is brittle, like glass. We can't use it."

So they're willing to go to hours of trouble to cut up a ruined British Brengun carrier or, prize haul of all, a General Sherman tank. Wasteful though they know it to be, they are willing to turn down a 6-inch shaft to make a $1^1/_2$-inch part when that part demands tool-steel hardness and trueness.

In the first critical months the welders of this repair shop were afoot half the time, carving armorplate out of abandoned tanks—abandoned because shot up. (Lieutenant Andell has his eye on four distressed Brenguns now, but they've been under four feet of water and could not be handled till the big rains quit.) Salvaged steel kept the first of the Road's rock crushers in operation when these essential machines had shaken themselves to pieces through overwork and no spare parts were available.

Salvaging is tedious business, but they figure it still saves time as against setting up a foundry and making molds and pouring the needed part, even if you could be sure of obtaining the right mix. And, of course, they get better steel. So they tell you pridefully they have within 10 months issued nearly 27,000 reclaimed parts—and right there they have saved the buyers of war bonds many millions of dollars and saved months of time in keeping the war drive moving forward against the Japs.

One replacement problem is seldom mentioned, for fear of someone losing face. That is the matter of new machinery arriving with important parts "missing." Trucks without carburetors, for instance. This sort of thing grows better daily as GI's take over more and more of the handling of America's goods-of-war with their own railroad battalions. But supplies are still a problem, and always will be in China and Burma. Air shipment all the way from the States is out of the question for such items as machine tools. What arrives by boat at Calcutta or Bombay is trans-shipped three or four times on various Indian railroads, changing from wide gage to narrow gage and to ferryboat and back to narrow gage. Things sometimes disappear, and usually the part or parts most needed.

But this outfit plugs along, trying to do a job and not moralize too much about the mistakes of other people. They have their job to do: a job they volunteered for and came overseas as a unit to handle. This Engineers heavy repair shop is made up of shopmen from the Caterpillar Tractor Company at Peoria, Ill. Their camp overseas is named "Little Peoria." When the call went out in the factory 1200 men volunteered. Only a portion could be taken, so the officers in charge skimmed the cream, selecting men with proved shop experience plus cheerful and adaptable personalities. Since the unit has been overseas over 60 of the enlisted men have turned down chances at OCS (Officer Candidate School). Captain Walker, for his part, has steadfastly refused promotion to Major so he could stay.

Back home the wives and sweethearts have set up a Women's Auxiliary. And news sent home quickly becomes neighborhood property.

Oddly enough, although located in the wilderness and living for a long time on rations dropped from the air, these Engineers keep themselves clean-shaven and reasonably neat. Neat for muddy Burma, that is. (And during the dry season the mud becomes dust. Joe E. Brown, the comedian, told General Lewis W. Pick that "this is the finest road I ever tasted." But the men don't complain about the mud or the dust. They turn out the work. All they want to do is to finish the Ledo Road and hook up with the Burma Road out of China, and let it perform whatever military function the Army leaders plan for it, so they can go back home. They're an earnest, willing, working lot of men and they don't like to see their efforts wasted. You and I, watching them rebuilding their heavy machinery with the scrap steel of war, agree with them that what they have done is so tremendous that it will be God's pity if it has been done needlessly, or in the wrong place, or at the wrong time. The Army campaign in Burma needs to succeed, if only to make good with the GI's who have built their lives into America's 1945 masterpiece, the 220-mile $1,000,000-a-mile Ledo Road.

SECTION ACTIVITIES

BOSTON

"Furnace Brazing" was discussed by H. M. Webber, Industrial Heating Division, General Electric Co., at the December 11th meeting of the Boston Section. Using Kodachrome illustrations, he described typical applications of furnace brazing, methods of supporting assemblies in the furnace and the types of equipment available. Mr. Webber has been connected with the Industrial Heating Division of General Electric Co. for sixteen years as an application engineer, specializing in controlled atmosphere furnace applications, with particular emphasis on electric furnace brazing.

Subjects for the remaining meetings of the season are:

Jan. 8th—A "New Oxyacetylene Development."
Feb. 12th—"Welding of Stainless Steel;" "Tempil° Products and Their Applications."
March 12th—"Welding in the Post-War World."
April 9th—"Magnaflux Testing of Welds;" "Electrodes."

CHATTANOOGA

The December meeting of the Chattanooga Section of the AMERICAN WELDING SOCIETY was addressed by L. G. Pickhaver, Welding Engineer, of the General Electric Co., Chicago, Dec. 8, 1944, on the subject "Atomic Hydrogen Arc Welding." The meeting was held in the auditorium of the Electric Power Board Building where the acoustics and facilities were perfect for the talk as well as the showing of the speaker's slides and the colored sound movie entitled "Atomic Hydrogen Welding."

In addition to his talk upon atomic hydrogen arc welding, Mr. Pickhaver also covered the gas-shielded arc-welding processes using either argon and helium as the protective agents. Samples of welding done by the various methods were shown the group and explanation given upon the procedures utilized.

Approximately 22 members and their guests gave careful attention to the address as was evidenced by the lively question and answer period that followed.

In the absence of the section chairman, Justin Brown, the meeting was conducted by R. G. Wilson, Secretary and Treasurer of the local group, and the speaker was introduced by Past-Chairman Pembroke Leach.

Considerable interest was expressed in the meeting scheduled for January when John B. Tinnon, Vice-President of Metal and Thermit Corp. will talk on "Thermit Welding."

CHICAGO

The third meeting of the Chicago Section, AMERICAN WELDING SOCIETY, for the 1944–45 season was held November 17th. The meeting was opened with a showing of a new movie on a.-c. welding entitled "The Story of A.-C. Welding."

The speaker of the evening was R. D. McComb, General Electric Co., Schenectady, who spoke on the subject "Electronic Controls for Resistance, Arc and Gas Welding Applications." In a highly informative talk couched in nontechnical language Mr. McComb pointed out the many possible applications of electronic controls in the fields of resistance, arc and gas welding as well as for flame cutting. In addition, illustrations were given of the other uses to which electronic controls are being put these days. The speaker particularly emphasized the importance of electronic controls in resistance welding and in automatic arc-welding applications. Without such controls it would be impossible to overcome many of the difficulties which would otherwise confront the users of these welding processes. Following this readily understood layman's explanation of electronic controls there was an interesting discussion period which dealt with the more technical phases of the use of these controls in welding.

CINCINNATI

The Cincinnati Section held their regular monthly meeting at the Engineers Club, December 5th.

The meeting was very well attended and those in attendance listened with interest to the talk that Frank Thompson, Jr., of the Thompson Engineering Co., Honolulu, gave on his subject of "Underwater Cutting and Salvage Operations at Pearl Harbor."

Mr. Thompson was born and reared in Honolulu, attending college in this country, and quite naturally an authority on the modes of living of the inhabitants, their form of government, the principal products these islands produce, and the very important part that welding and cutting of metals play in the everyday life of this group of islands.

He gradually led up to the fatal day of Dec. 7, 1941, when the Japs struck Pearl Harbor and left thinking they had sunk the entire Pacific fleet. "But," says Mr. Thompson, "they did not reckon with the fight and determination we had in us, and rescue work and salvaging went speedily forward, and with the aid of underwater cutting torches and electric welding, we have raised up those ships and are giving the Japs a dose of their own medicine."

The January meeting of the Cincinnati Section will be held at the Cincinnati Milling Machine Co. Plant inspection is to be followed with the regular meeting and buffet lunch.

The following officers have been elected by the Cincinnati Section: *Chairman*, George A. Jacoby; *Vice-Chairman*, Rowan Gilbreath; *Treasurer*, Ernest F. Cahn; *Secretary*, Larry E. Sherman.

CLEVELAND

"Hard Facing" was the subject of a talk by Tom J. Crawford, Youngstown, Ohio, consulting engineer, when he spoke before the Cleveland Section meeting December 13th, at the Cleveland Engineering Society Building.

Mr. Crawford, formerly with the Republic Steel Corp., in charge of research and development, gave a very practical job application discussion of hard facing with particular reference to applications in steel mills.

A buffet lunch was served after the meeting, continuing for the second time an idea which was staged very successfully at one of the programs of the preceding year.

A hard-working membership committee has brought in 17 new members during the last month and they are continuing their excellent efforts to increase the size of the Cleveland Section.

The Cleveland Section is looking forward with interest and anticipation to the establishing of a new section of the AMERICAN WELDING SOCIETY in Erie, Pa. It is understood that plans are being made for the organization of such a section.

COLUMBUS

The November meeting of the Columbus Section held on the 14th was a joint meeting with the American Society for Metals. Dr. C. C. Furnas, Director of Research, Curtiss-Wright Corp., Buffalo, N. Y., spoke on the subject "Next Twenty-five Years in Aviation."

The December meeting held on the 8th at the Southern Hotel, was addressed by L. A. Kotrascheck of the Picker X-Ray Corp., who spoke on "X-Ray Examination of Welds." A film, "Engineering X-Ray Inspection," was shown through the courtesy of the U. S. Dept. of Education.

Meetings of the Columbus Section scheduled for the remainder of the season are:

Jan. 12th—at Battelle Memorial Institute, "Development of Pressure Welding," by Dean C. E. MacQuigg, O.S.U.; Film, "Pressure Welding."
Feb. 9th—Dinner Meeting at Southern Hotel; National Cylinder Gas Co.; "Why Different Types of Electrode Coatings," by R. E. Long, Chief Engineer, National Cylinder Gas Co., Hollup Corp.
March 9th—Dinner Meeting at Southern Hotel; "Multi Arc Welding of Aluminum Alloys," by C. D. Steward, Curtiss-Wright.
April 13th—Dinner Meeting at Southern Hotel; "Welding in the Postwar

World," by T. B. Jefferson, Editor, *The Welding Engineer*.

May 11th—Film, "Aircraft Welding," by U. S. Navy; Entertainment; place to be announced later.

On all above dinner meetings, please make reservations with Secretary of Section. Technical sessions start promptly at 8:00 P.M.; dinner promptly at 6:45 P.M.

DETROIT

A symposium on resistance welding of heavy sections attracted a large turnout of members of the Detroit Section to the Rackham Memorial Bldg., on December 1st. Speakers were Mario Sciaky, of Sciaky Bros., Chicago, and C. F. Leathers of Progressive Welder Co., Detroit. A number of members of the Cleveland Section, together with national officers, attended as guests.

The Sciaky balanced three-phase supply circuit was discussed in detail by the first speaker. He outlined the advantages of a system of power feeding which starts with high pressure combined with low voltage to reduce the surface; and continues in phases of high pressure and high current, high current and low pressure, then reduced current with resumed high pressure. Wiring setups on slides described the hookups of three-phase welding.

Mr. Leathers pointed out that storage battery welders, such as are produced by his company, can function on current from an ordinary power line or from a small generator set operating through a rectifier. Mr. Leathers, like Mr. Sciaky, showed a number of slides demonstrating adequate resistance welding of medium and heavy sections of steel. A spirited discussion followed the talks. A battery welder of Progressive Welder Co., on the stage of the auditorium, was used to demonstrate this new technique in welding.

KANSAS CITY

The December meeting of the Kansas City Section was held on Tuesday, the 12th, in the Pine Room at the Union Station. Dinner was served at 6:30 and the meeting was called at 8:00. The speaker was M. C. Robbins of Handy and Harman. Mr. Robbins spoke on "Low Temperature Brazing," which was followed by a discussion period.

T. B. Jefferson, Editor of *The Welding Engineer*, spoke on "Welding in the Postwar World" at the November 21st meeting held in Fred Harvey's Pine Room, Union Station. Discussion followed.

F. L. Goldsby of the Chicago Bridge and Iron Co. gave a very interesting talk, entitled "Design for Welding" at the October 24th meeting. He emphasized the general points of designing which are so often overlooked.

LEHIGH VALLEY

The Lehigh Valley Section's regular monthly meeting, which was a joint meeting with the Lehigh Valley Chapter of the American Society for Metals, was held at the Hotel Bethlehem on December 4th.

The seventy members and friends present at the dinner heard a timely and interesting dinner talk by Prof. P. B. Eaton of Lafayette College. Prof. Eaton has recently returned from the Far East and spoke on "Our Ally, China." The speaker emphasized that China is fighting valiantly in spite of her meager equipment and supplies.

Prof. Eaton predicted that by July 1, 1945, the United States will have established bases on the China coast and the final defeat of the Japs will be accomplished by American Air Power and Chinese Infantry. Also, the foundation for peace and security in the postwar world is dependent on friendly relations between the United States and China.

The technical session, presided over by Chairman J. W. Kenworthy was attended by 150 persons. Dr. R. D. Stout of Lehigh University, whose work on weldability research is well known, spoke on "Ductility of the Weldment in the Heat-Affected Zone."

Dr. Stout pointed out that in high-carbon and low-alloy steel, embrittlement of the weldment in the heat-affected zone may become serious. The degree of embrittlement is dependent upon the cooling rate of the weldment and the cooling rate is dependent upon the heat input, the initial temperature and the joint design.

Dr. Stout also explained the use of the Jominy bar and the notch bend test as an index of the ductility of weldments. During the lively discussion which followed Dr. Stout's talk, it was pointed out that much data need be gathered on the degree of ductility which a safe structure requires.

The next meeting which will be a panel discussion will be held in the Hotel Bethlehem on Feb. 5, 1945. H. O. Hill of the Bethlehem Steel Co. will be the moderator for this discussion.

LOUISVILLE

The November Panel Meeting with an address by E. F. Schulz, Supervisor of Welding and Cutting, L & N Railroad Co., was well attended and Mr. Schulz's subject, "Railroad Welding," was highly enlightening and instructive. We made an especial appeal to the welding operator, leadman, foreman, supervisor and superintendents to bring welding problems and "headaches" as they occur to the meetings for discussion and possible solution. Also the members were encouraged to write down "knotty ones" on a form provided for the occasion for study and analysis. Floor discussions followed.

A color-sound-film "Vacation in Adventure Land," Glacier National Park, proved its worth and rounded out a well-balanced program. The film was made possible by the courtesy of Charles W. Moore, Advertising Department, Great Northern Railway Co., St. Paul, Minn.

"Welding in the Postwar World" as presented by T. B. Jefferson, Editor, *The Welding Engineer*, Chicago, was well received and acclaimed by an appreciative audience of some 125 members on Tuesday, Nov. 28, 1944. This dinner meeting marked the close of our Section's Social Activities for the current year, with having passed the "December Dinner Date" for the members' other personal diversions. This "fill the Christmas stocking" and the "New Years' Resolutions" period will be followed by our Jan. 22, 1945, meeting.

Some of our "heavy-thinking" members voiced the opinion that our—AMERICAN WELDING SOCIETY child—had been too dressed-up and possibly a little high-hat on occasions so we added entertainment. The Mivelaz Orchestra played dinner music acceptably in "welding airing" us and, the appropriately dressed Twin Sisters, who are welders, sang in good time, rhyme and motion. They were billed as "Irene and Corene: The Singing Welding Twins." Before Mr. Jefferson's talk which headlined the affair, James A. Yonder, local Humorist and Monologist took over with telling effect. In summation: The change-over really went over.

Mr. Jefferson was presented "A Certificate of Appreciation" appropriately framed for wall decoration by Theodore Lewis, Chairman.

MILWAUKEE

The regular monthly meeting of the Milwaukee Section was held on November 17th at the Ambassador Hotel. Dinner at 6:45 preceded the meeting at 8:0 S. I. Rochwite of David White Co., gave an after dinner talk on the subject "Stereo—Three Dimensional Pictures."

The Welding Address was presented by Arthur Schwarz of the John Nooter Boiler Works Co., St. Louis, Mo. Mr. Schwarz subject was on "Problems in Fabricating Alloy Equipment."

NEW JERSEY

The November meeting of the New Jersey Section was held on the 21st at the Essex House, Newark, N. J. Dinner at 6:30 preceded the program. An "Information Please Session," with A. B. King of the Federal Shipbuilding and Dry Dock Co., as chairman, was held between 7:45 and 8:15 P.M.

Two illustrated talks, one on "Controlled Atmosphere Furnace Brazing" by A. K. Phillippi of the Westinghouse Electric & Mfg. Co., Springfield, Mass., and "Low Temperature Joining" by C. E. Swift of the Eutectic Welding Alloys Co., New York City, were presented.

Mr. Phillippi's talk covered various types of equipment used in furnace brazing as well as the methods of procuring the various atmospheres and the necessities of these atmospheres.

Mr. Swift's talk covered the theory of low-temperature welding.

The December meeting held on the 19th at the Essex House, Newark, was as usual preceded by dinner at 6:30 P.M. The "Information Please" Session, with

Hansen of the Foster Wheeler Corp., as chairman, was held between 7:45 and 8:15 P.M.

A film "Synthetic Rubber" was shown and was followed by a talk by E. J. Wellauer, Supervisor of Research and Metallurgy for The Falk Corp., Milwaukee. Mr. Wellauer's talk covered the engineering and metallurgical properties of cast steel suitable for welding; the factors of design and specification required to insure satisfactory castings for welding and the economies of steel castings for weldments including typical examples.

NEW YORK

The regular monthly technical meeting of the New York Section was held on Tuesday, Dec. 12th, at the Engineering Societies Building. Mr. William Spraragen, Editor of THE WELDING JOURNAL, presided as Technical Chairman.

The New York Section tried a type of meeting which for that section at least was an innovation and experiment. The enthusiastic reception of those in attendance warrants the recording of this idea for possible use by other sections. The general plan was to bring a review of the highlights of the Annual Meeting in Cleveland in October to the local section membership. The 58 papers that were presented at the Annual Meeting were broken down according to processes in the following four groups: arc welding, gas welding and cutting, resistance welding, scientific and metallurgical. Highlights of other papers that did not fit too well into these groups were covered by the general chairman who also led the discussion and introduced the speakers.

The speakers who covered the four groups were as follows: Prof. O. H. Henry, Brooklyn Polytechnic Institute; H. O. Klinke, Air Reduction Sales Co.; H. B. Axtel, Taylor-Winfield Corp.; C. J. Burch, The Linde Air Products Co.

All of the speakers had heard most of the Annual Meeting papers which they discussed. Their presentation was in the form of a digest or abstract of the information, rather than mere repeating of statements or paragraphs from the original. Credit to the original author or authors was given but the presentation was so conducted that the audience had the feeling that the speaker was familiar with the subject and therefore was in a position to discuss it with authority. This seemingly unimportant refinement actually contributed in large measure to the success of the meeting.

The general basic theme of the research papers dealt with the effect of the metallurgical and physical conditions of the weld metal and adjacent base metal on the subsequent behavior of the final assembly when in actual service. Prof. Henry covered in a brief way some of the specific problems, the method of attack and the results obtained.

The papers presented on arc welding seemed to Mr. Klinke to emphasize three outstanding points: quality and cost control of the arc-welding process; multi-arc welding of the high-strength aluminum alloys; and procedure control of welding in shipbuilding. He showed how these have developed during the war period and discussed their possible post-war effects.

Important developments in resistance welding that Mr. Axtell discussed included the first detailed description of the method of preforming spot welder electrodes for greater service life. The subjects of equipment innovations and flash-butt welding rounded out Mr. Axtell's discussion.

Among the significant developments in the oxyacetylene process which Mr. Burch touched on were: solid phase welding and its applications; a rational approach to heavy cutting; unusual applications of gas cutting to achieve accuracy and economy; and expansion of the welding process to aid in steel mill maintenance.

All of the speakers did a commendable job in covering their respective subjects, resulting in a meeting that was so loaded with interesting practical information that the question and answer session had to be brought to a close by Chairman Spraragen after nearly an hour of animated discussion. The actual presentation of the papers consumed about one hour and 15 minutes and the informal part extended a considerable period after that, in spite of the length of the formal part of the meeting.

NORTHERN NEW YORK

The regular meetings of the Northern New York Section for the next few months are as follows:

Jan. 25—"Experimental Stress Analysis Applied to Welding," by H. R. Sennstrom, Supt., Applied Mechanics & Electronics, Research Laboratory, American Locomotive Co.

March 1st—General meeting of coordinated Societies; The "Duck," by J. M. Diebold, Welding Engineer, General Motors Corp., GMC Truck & Coach Division.

March 22nd—"Welding Aluminum and Magnesium," by G. O. Hoglund, Engineer, Aluminum Co. of America.

April 26th—Resistance Welding (subject to be announced later), by G. N. Sieger, President & General Manager, S.M.S. Corp.

NORTHWEST

The regular monthly meeting of the Northwest Section was held on December 6th at Coffman Memorial Union, University of Minnesota. R. F. Helmkamp, Service Engineer, Applied Engineering Dept., Air Reduction Sales Co., New York, spoke on "Recent Developments in Machine Gas Cutting."

OKLAHOMA CITY

A meeting was held on Friday, Dec. 1, 1944, at 8:00 P.M., Biltmore Hotel. The guest speaker was T. B. Jefferson, Editor, *The Welding Engineer*, Chicago, Ill. The subject of Mr. Jefferson's address was "Welding in the Postwar World."

Mr. Jefferson discussed step by step the vast expansion in the welding industry during the war period and the possibilities of the industry remaining big business in the postwar era. Three major problems will face the welding industry following the war: (1) jobs; (2) production; (3) taxes.

Following Mr. Jefferson's principal address he discussed the highlights of his experience as Assistant Plant Engineer with the U. S. Army Engineers on the $120,000,000 Fort Peck, Montana, Dam Project.

His address was preceded by a recent motion picture release by the Harnischfeger Corp., entitled "Welding Horizons."

Preceding the meeting, the speaker was guest at a dinner given by the Officers and Executive Committee of the Oklahoma City Section. W. S. Gleason was appointed to serve the unexpired term as Membership Chairman of J. S. Cook who recently resigned.

The next regular meeting was held on December 14th, at which time we had as our guest speaker M. C. Robbins, Handy & Harman, Chicago, Ill., whose subject as "Low Temperature Brazing."

PASCAGOULA

The AMERICAN WELDING SOCIETY held its monthly meeting at the USO Hall, Tuesday evening, Oct. 31st. This was an open meeting attended by eighty-five members and guests of the organization. The recently formed Pascagoula Section of the AMERICAN WELDING SOCIETY has grown rapidly. All members are enthusiastically backing the club 100%.

The open meeting Tuesday evening was a dinner gathering at which LaMotte Grover, welding engineer from the Air Reduction Co., was guest of honor and speaker of the evening. A delicious chicken dinner was served, after which the meeting was called to order. Welding Superintendent W. B. Bowen, chairman, opened the meeting by introducing Milton Forman, secretary and treasurer of the Pascagoula Section, who gave a brief talk on the "Prospectives of the Pascagoula Section of A.W.S."

R. H. Macy, Ingalls planning engineer and chairman of the program committee, announced future programs to take place in the next two months, stating guest speakers will be alternated by having a local person one month and a visiting speaker the next. Mr. Forman spoke at the last meeting, which was held Tuesday, November 28th. His talk was on "Shipfitting."

W. R. Guest, Ingalls executive vice-president, was then introduced, and spoke briefly on the interest and backing which will be given the A.W.S. by the Ingalls Company, and also announced that the company had taken a sustained membership in the organization. He also said he was glad to see such a large turnout and hoped the total membership would soon reach one hundred, and the growth of the organization had been remarkable. After all, it should be, for it has grown out of a group of men from an all-welded shipyard.

A. M. Swigert, Ingalls works manager,

stated he was glad to be among those present, and expressed his pleasure at seeing the organization progressing so successfully. Mr. Swigert then introduced Lamotte Grover, who spoke on "Gas Cutting and Welding in Ship Construction." Mr. Grover gave a well-planned illustrated talk, both from a technical and nontechnical viewpoint, which fitted the mixed members of the group. After the talk a discussion was held, in which Mr. Grover answered questions pertaining to welding problems. The meeting was a satisfactory one according to the committee of the A.W.S.

PHILADELPHIA

The third regular meeting of the season of the Philadelphia Section was held on November 20th at the Engineers' Club. A. Amerikian, Engr., Bureau of Yards and Docks U. S. Navy, spoke on the subject "Structural Engineering and Welding."

PITTSBURGH

Nearly 150 members and guests heard Frank E. Thompson, Jr. of the Thompson Engineering Co., Grand Rapids, Mich., give a most interesting talk on the "Salvage Operations at Pearl Harbor on and after Dec. 7, 1941," Wednesday night, November 15th, in the Mellon Institute.

While not permitted to show motion pictures of the havoc wrought and the ways and means used to repair and replace the damage, Mr. Thompson gave a very clear word picture of the entire operation, including both civilian and military problems encountered before and after the country was plunged into war.

Description of the unique applications of under-water welding and cutting interested all those present and on completion of his talk Mr. Thompson was highly complimented.

Following the usual custom of the Pittsburgh Section no regular meeting was scheduled for December. However, the next meeting Jan. 17, 1945, will bring C. E. Betz, vice-president, Magnaflux Corp. of New York who will present a discussion on Weld Testing.

PORTLAND, MAINE

The November meeting was held at the Elks Home, Portland, Me., and although the Section was handicapped by a typical "Main North Easter" there were still about 40 members who were interested enough in the SOCIETY to brave the elements and attend.

Following a fine dinner, the members were most interestingly entertained by H. C. Hoganboom who spoke on "High Pressure Pipe and Pipe Casting Welding," using picture slides for illustration.

A brief roundtable discussion in which most everyone took part, proved helpful and brought the meeting to a close.

PUGET SOUND

The November dinner meeting was held on the 29th at the Gowman Hotel, Seattle, Wash. A Question Box Discussion by Joe Holt of Webster-Brunkley Co., and also a report of the 1944 Metal Congress was held between 6:30 and 7:00. Dinner was at 7:00 P.M.

An address on "High-Strength Spot-Welded Joints" was presented by Marshal Crawford, Process Engineer, Boeing Aircraft Co. The development of the joint of which Mr. Crawford spoke was largely due to his efforts.

ROCHESTER

Dinner at the Century Sweet Shoppe preceded the regular meeting of the Rochester Section held on November 2nd. The meeting was held in the Lower Strong Auditorium, University of Rochester, River Campus. R. F. Helmkamp, Applied Engineering Dept. of Air Reduction Sales Co., spoke on "Recent Developments in Machine Gas Cutting."

Newly elected officers of the Rochester Section are: *Chairman*, Paul A. Ecklund, Delco Appliance Co.; *Vice-Chairman*, Edward G. Hable, Eastman Kodak Co.; *Secretary*, Edward R. Jones, Allan Iron & Welding Works, Inc.

The December meeting held on the 7th was also preceded by a dinner at the same place. The meeting, however, was held in Room 208, Engineering Department, University of Rochester, River Campus. After preliminary discussion the group went into the Laboratory where various standard tests of welded joints were demonstrated on both satisfactory and faulty welds. Various sample and micrographs of welded joints were on display.

A bowling party will be held on January 13th at the Ridge Bowling Hall, 8:00 P.M.

ST. LOUIS

The regular meeting was held on November 10th at the Engineers' Club Auditorium. The subject of the meeting "Welded Vessels—Notes on Inspection and Codes" was presented by Robert G. Milligan, Supervising Engineer, The Ocean Accident and Guarantee Corp. Ltd. Mr. Milligan gave a very interesting talk on the application of A.S.M.E. and A.P.I. Code as applied to welded vessels. His talk was profusely illustrated with slides and five specific cases were presented and described covering failures of both welded and riveted vessels in the field.

A premeeting movie, "Invasion—Nazi Version" a captured film taken by the Nazis of Allied landings on D-Day, was shown.

SAN FRANCISCO

The November Meeting of the AMERICAN WELDING SOCIETY, San Francisco Section, was held at the Engineers' Club, San Francisco, Calif., on Monday, Nov. 27, 1944, with Chairman, C. M. Doggett, presiding.

There were 90 members and guests in attendance.

The Chairman made an announcement of a Resolution adopted by the Executive Committee in the San Francisco Section for presentation for the membership, as follows:

Arrangements are being made to provide each member with an official A.W.S. badge to be worn by all members and guests at each of the regular monthly meetings. These badges will be issued at the beginning of each meeting assigned to each member by number and badges to be provided for their guests. All badges are to be returned at the end of the meeting to the Badge Committee upon leaving the meeting place. It was further purposed that each member be fined the sum of 25 cents if he neglects to turn in his badge at the end of the meeting (that is, if he takes his badge home). Cost of badges to approximate 4 cents each.

After the regular business had been attended to, the meeting was turned over to David Zuckerman, Technical Chairman for the evening. Mr. Zuckerman introduced Donald G. Maxson, who presented a talk on "Controls Required for Safe and Economical Construction of Welded Ships." Mr. Maxson, a Graduate Naval Architect and Marine Engineer of Webb Institute in Naval Architecture, was well versed in his subject. His background as Welding Engineer and Consultant with Electric Boat Co., Manitowac Shipbuilding Co., Bechtel Shipyards, California Shipbuilding, Evansville Shipyard, and Marinship Corp. stood him in good stead in the preparation of his most interesting paper.

Mr. Maxson drew a word picture of the difficulties which are encountered as a result of residual stress in welded ships. His enlightening discourse provided each of us with a new outlook and fomented ideas for better and closer control.

The question and answer period following brought to light many interesting points and divergent ideas, all of which were thoroughly discussed and very ably handled by the speaker.

The meeting adjourned at 9:45 P.M.

After the meeting, the sound motion picture entitled "The Return to Guam" was shown. This film was obtained through the courtesy of the U. S. Navy. The stereopticon was supplied through the courtesy of General Electric Co. and the motion picture equipment through the courtesy of Victor Equipment Co.

Many thanks to our very accommodating operator, W. A. Bragg.

TOLEDO

There was no October meeting in Toledo, because the AMERICAN WELDING SOCIETY was holding its annual meeting in Cleveland during the same week.

Several of the officers and members attended some of the technical sessions as well as the metal show.

Those left behind, however, had the opportunity to attend the Toledo Technical Council meeting of such a timely subject as, "Rockets and Jet Propulsion." The speaker was G. Edward Pendray, Assistant to the President of Westinghouse Electric and Manufacturing Co.

A. J. Williamson, Chief Metallurgist for the Summerill Tubing Co. was

speaker for our November meeting. His subject was, "Welding Low-Alloy High-Strength Steels, Especially Aircraft Tubing and Sheet." The speaker's presentation and the slides which he used, gave technical facts which were found and established in a government-sponsored program at Battelle Institute. Government approval to make these facts public had just been obtained and the paper was read publicly for the first time before the Toledo Section. In all probability it will be published in the JOURNAL in due time.

At the beginning of the meeting a short film, G.E., part 1, of "A.-C. Arc Welding" was shown.

There were about 24 members and guests present.

The Board of Directors at one of the earlier meetings voted to hold our regular meetings always on *the third Tuesday* of the month, as was the custom last year.

WASHINGTON, D. C.

The Washington Section held its second meeting of the '44–'45 season on Tuesday, November 28th, at the Pepco Auditorium. Chairman C. E. Jackson introduced Gustav O. Hoglund, engineer of the Aluminum Co. of America, to the large audience which had gathered to hear the speaker discuss "Welding and Brazing of Aluminum."

Mr. Hoglund reviewed some of the metallurgical aspects of aluminum, by way of introduction, such as the strength problem of pure aluminum being overcome by the use of various alloying elements and subsequent heat treatments. What is being done and how aluminum is welded was ably described in patient detail. Thickness of material, joint preparation, distortion problems, bracing and aligning, all variables encountered in welding aluminum were only some of the items the speaker covered in his discussion of welding pressure vessels, beer barrels, cooking utensils, structural parts, etc. In mentioning the soundness of aluminum welds, Mr. Hoglund pointed out that preheat of the parts will aid in minimizing porosity, drying the electrodes also helps toward this aim. The electrode coating is flux designed rather than to afford atmospheres at the arc. Describing the arc-welding processes the speaker indicated that there was no upper limit to plate thickness for this type welding. Excellent use is made of the carbon arc and automatic welding at speeds of 28 in. per minute is commonly successful.

In discussing brazing alloys of aluminum, Mr. Hoglund described some of the engineering features and design purposes of intricate assemblies. It was of interest that the fatigue resistance of brazed joints is usually better than welded joints and affords less stress raisers at fillets and other joints. In closing his discussion the speaker described how brazing could replace many structures made by the casting process.

A motion picture with sound, "How to Weld Aluminum," was exhibited and showed the steps involved in fabricating aluminum by means of gas, electric and carbon arc welding. Torch, furnace and dip brazing processes were also excellently presented in the film.

After the meeting the members and guests were treated to refreshments and casual banter.

Officers of the Section are: *Chairman*, C. E. Jackson, Naval Research Lab.; *Vice-Chairman*, S. W. Trainer, Harnischfeger Corp.; *Secretary*, G. G. Luther, Naval Research Lab.

WESTERN MASSACHUSETTS

The November meeting of this Section was held on the 20th at the Springfield Trade School. D. A. Watson of the Metallizing Engineering Co. spoke on "Commercial Application and History of Metallizing." Following Mr. Watson's talk, the film "Aircraft Welding" was shown to an enthusiastic audience of about 70.

WESTERN MICHIGAN

Dr. Walter J. Brooking, Director of Testing and Research, R. G. LeTourneau, Inc., Peoria, Ill., was the guest speaker at the November 27th meeting held at Rowe Hotel, Grand Rapids. Dr. Brooking's illustrated talk was on "Welding Symbols and Procedure Control," and was very well received.

WESTERN NEW YORK

The regular November meeting was postponed from the last Friday in November until December 1st in order to avoid complications with Thanksgiving and was held in the regular location at the Forty & Eight Club, 891 Delaware Ave.

After the 6:30 dinner meeting, the regular business meeting took place at which time members heard an interesting talk by George E. Bellew, Foundry Specialist with Air Reduction Sales Co. on the "Machine Cutting of Risers."

This talk was illustrated with slides and very ably presented the problems and solutions encountered in flame scarfing to remove padding and flame gouging to remove webs and defects.

The next scheduled meeting will be the last Friday in January.

YORK-CENTRAL PENNSYLVANIA

The York-Central Penna. Section of the AMERICAN WELDING SOCIETY, at its meeting of Nov. 8, 1944, turned out in force to hear a talk on Clad Steel by H. S. Blumberg of the M. W. Kellogg Co. of Jersey City, N. J. Seventy members and guests attended this meeting.

C. E. Lewis Kerchner, chairman, opened the meeting and disposed of current business matters. His announcement that the new membership campaign is meeting with pronounced success was met with a round of applause. Numerous new members were introduced from the floor. Mr. Kerchner had E. J. Brady, past-chairman, introduce the speaker of the evening.

Those members and their guests who attended this meeting were amply repaid inasmuch as Mr. Blumberg's talk proved to be one of the most interesting and enlightening delivered before the Chapter in recent years.

The talk was well prepared and delivered both from the technical and practical application aspects, Mr. Blumberg's talk revealing his sound knowledge of his subject and the audience gained by his presentation of this knowledge in a clear, understandable manner. All phases of the Clad Steels such as types, manufacture, welding procedures, processing and forming, good and bad features, etc., were touched upon and each in turn resulted in numerous questions being put to Mr. Blumberg.

The open discussion period was lead by Vice-Chairman W. C. Bauer.

The audience showed its appreciation by its close attention and sincere applause at the end of the meeting.

The meetings of the York-Central Penna. Section for the next few months are:

Feb. 14th—Subject: "Welded Ship Construction. Future Place of Welding in This Industry," by T. M. Jackson, Electrical Engineer, Sun Shipbuilding & Drydock Co.

March 14th—Subject: "Conversion to Welded Steel. Welded Steel Products Development," by E. J. Charlton, Assistant to President, Lukenweld, Inc.

April 11th—Annual Meeting and Dinner; General Electric—House of Magic.

May 9th—York-Central Penna.—Coatesville Meeting as the guests of Lukens Steel Co. Members only.

MILLER MEDAL AWARD NOMINATIONS

The Committee on Awards of the AMERICAN WELDING SOCIETY wishes to announce that it would like to obtain the active cooperation of all members of the SOCIETY in the selection of the recipient of the Miller Medal for the current year.

This is an honor that is greatly prized and is given "to the person who in the judgment of the Board of Awards is most deserving for conspicuous contributions to the advancement of the welding or cutting of metals."

Many members of the SOCIETY have personal acquaintance with, or knowledge of, individuals who they feel should be considered for this honor. The Committee on Awards would be glad to receive letters suggesting names and giving reasons for their suggestions.

Please mail these proposals before February 15th to E. M. T. Ryder, Chairman, Committee on Awards, 2396 Third Ave., New York 35, N. Y.

Send Suggestions for
ANNUAL MEETING PAPERS
to W. Spraragen
American Welding Society
33 W. 39th St., New York, N. Y.

List of New Members

November 1 to November 30, 1944

BIRMINGHAM

Bischoff, Floyd W. (C), P. O. Box 1324, Birmingham 1, Ala.
Mattes, Frank J. (C), Snyder Tank Corp., P. O. Box 2390, Birmingham, Ala.
Nelson, Arthur L. (C), Chicago Bridge & Iron Co., 4200—40th Ct. N, Birmingham 7, Ala.
Richards, Paul S. (C), P. O. Box 2390, Snyder Tank Corp., Birmingham, Ala.

BOSTON

Connolly, Frank J. (B), 30 Wildwood St., Winchester, Mass.
Hiteshew, C. Phillip (C), 69 Telegraph St., S. Boston, Mass.

CHATTANOOGA

Peek, Horace H., Jr. (C), Lookout Boiler & Mfg. Co., Chattanooga, Tenn.

CHICAGO

Killen, William L. (C), 7150 Eggleston Ave., Chicago 21, Ill.
Lee, Earle S. (B), Champion Rivet Co., Cedar Lake, Ind.
Loudy, W. L. (B), American Products Corp., 422 S. Dearborn St., Chicago 5, Ill.
Moosman, Lillian S. (C), 670 N. Elizabeth St., Lombard, Ill.
Owen, John C. (B), 9541 S. Damen Ave., Chicago, Ill.
Robinson, Geo. E. (B), New York Central R.R., 425 La Salle St. Sta., Chicago 5, Ill.

CLEVELAND

Hartman, Roy F. (B), 329 Plum St., Tipp City, Ohio.

DETROIT

Barta, Wesley J. (C), American Bureau of Shipping, 1303 Majestic Bldg., Detroit 26, Mich.
Brown, Ralph (B), Defoe Shipbldg. Co., Bay City, Mich.
Dickinson, George L. (C), 1029 E. Yale Ave., Flint 5, Mich.
Dougherty, Raymond L. (C), W. M. Chace Co., 1600 Beard, Detroit 9, Mich.
Gordon, John D. (A), Progressive Welder Co., 3050 E. Outer Dr., Detroit 12, Mich.
Hall, William E. (C), 8375 Military, Detroit 4, Mich.
Hawes, Collins (C), 2050 N. York, Dearborn, Mich.
Hogrefe, Otto L. (B), 2018 Colon St., Flint, Mich.
Kiilunen, Matt (C), 15427 Fairfield Ave., Detroit, Mich.
Moore, Lloyd T. (C), 35732 Goddard Rd., Romulus, Mich.
Thatcher, James D. (C), 1909 Mallory St., Flint 4, Mich.
Whitehouse, W. E. (B), Defoe Shipbldg. Co., Bay City, Mich.

HARTFORD

La Pointe, Camille F. (B), La Pointe Welding Service, 21 Dewey St., New Britain, Conn.
Studzinski, Richard S. (B), The State Welding Co., 25 John St., Hartford, Conn.

HAWAII

Chun, William K. (C), Hawaiian Gas Prods., P. O. Box 2454, Honolulu 4, T. H.

INDIANA

Bohnstedt, Harold A. (C), 336 Lockburn St., Indianapolis 8, Ind.
Krapf, Edgar A. (C), Link Belt Co., Ewart Wks., 220 S. Belmont, Indianapolis 6, Ind.
Lentz, Jefferson (C), Box 64, Jasper, Ind.
Watson, John W. (C), 3424 W. Washington St., Indianapolis 8, Ind.

KANSAS CITY

Brown, Zennas (B), 1019 E. 8th, Wellington, Kan.
Burnidge, M. X. (B), 204 W. Madison, Pittsburgh, Kan.
Pole, Frank (C), 109 S. Park, Independence, Mo.

LEHIGH VALLEY

Stametz, Stanley (C), 54 W. Ettwein, Bethlehem, Pa.

LOS ANGELES

Alexander, Frank B. (C), General Testing Lab., Calif. Shipbldg. Corp., Wilmington, Calif.
Beagley, Edwin Reed (C), Western Pipe Steel, 5717 Santa Fe, Los Angeles, Calif.
Blake, Donald K. (C), 902 Cabinet Dr., San Pedro, Calif.
Brooks, L. S. (C), 4915 Nevada St., Bell, Calif.
Buettner, Fred J. (C), 3151 Josephine St., Lynwood, Calif
Clarke, B. C. (A), Pacific Metals Co. Ltd., 1400 S. Alameda St., Los Angeles, Calif.
Frazier, Harry V. (C), 828 E. 94th St., Los Angeles 2, Calif.
Garcia, Manuel D. (C), 918 Agatha St., Los Angeles 21, Calif.
Gillis, Delbert B. (C), 235 W. Queen St., Inglewood, Calif.
Knaak, Otto A. (C), 1143 E. 103rd Pl., Los Angeles 2, Calif.
Koenig, Frederick P. (C), 3850 Gundry Ave., Long Beach 7, Calif.
Mead, Eugene H. (C), 1404 W. 7th St., Los Angeles, Calif.
Mock, Elden J. (C), 10415 Kauffman Ave., South Gate, Calif.
Naylor, John R. (C), 8949 South Gate Ave., South Gate, Calif.
Rebman, Henry (C), 4214 E. 60th St., Huntington Pk., Calif.
Rynearson, Roy J. (C), 2054 Magnolia Long Beach 6, Calif.
Skinner, Paul (C), 331 E. Elliott, El Monte, Calif.
Swinehart, Herbert M. (B), Southwestern Eng. Co., 4800 Santa Fe Ave., Los Angeles 11, Calif.
Troxell, Othello K. (C), 9637 Victoria Ave., South Gate, Calif.
Ufholtz, J. J. (C), Western Pipe & Steel Co., 5717 Santa Fe Ave., Los Angeles 11, Calif.
Verran, Frank (C), 2907 Liberty Blvd., South Gate, Calif.

LOUISIANA

Wilson, R. P. (B), The Linde Air Products Co., 832 Howard Ave., New Orleans, La.

LOUISVILLE

Bomersbach, N. L. (C), Floyd Knobs, Ind.
Schneider, C. J. (C), Mineweld Co. of Ky., 737 E. Broadway, Louisville, Ky.

NEW JERSEY

Aitken, Geo. L. (C), 28 Elizabeth Ave., Newark, N. J.
Bluhm, James D. (C), 530 Park Ave., G. 2., Orange, N. J.
Essig, Frederick (C), 119 Prospect Ave., N. Arlington, N. J.
Kime, Allan B. (B), 3 Oxford Place, Newark, N. J.
Leming, Paul W. (B), Crocker-Wheeler Elec. Mfg. Co., Div. Joshua Hendy Iron Wks., Ampere, N. J.
Rush, Harold W. (C), Dover Boiler & Plate Fab., Marvin St., Dover, N. J.
Strangia, M. (C), 60 Logan Ave., Jersey City, N. J.
Work, Dr. Lincoln T. (B), Metal & Thermit Corp., P. O. Box 255, Rahway, N. J.

NEW YORK

Berner, John (C), Multi-Metal Wire Cloth Co., Inc., 1350 Garrison Ave., Bronx 59, N. Y.
Chern, Vadim A. (B), 15 Gramercy Park, New York 3, N. Y.
Egbert, Harold (C), 40 Cortland St., Staten Island 2, N. Y.
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Joynes. Thomas M. (B), 408 Walnut St., E. Bound Brook, N. J.
Miller, John E. (C), 80-11—190th St., Jamaica, N. Y.
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Sussman, William (F), 649 Park Ave., East Orange, N. J.
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Wilker, Joseph (C), Multi Metal Wire Cloth Co., Inc., 1350 Garrison Ave., Bronx 59, N. Y.

NORTHERN NEW YORK

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NORTHWEST

Collins, Joseph E. (B), 5548 Stevens Ave., Minneapolis 9, Minn.
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Mendenhall, Harold (B), Flame Processing & Mfg. Co., 213—7th St., S. E., Minneapolis 14, Minn.

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Adams, Oscar (C), 515 N. Dewey, Oklahoma City 3, Okla.
Beam, J. E. (C), Oklahoma City Hardware Co., P. O. Box 1537, Oklahoma City, Okla.
McKoske, J. J. (C), Osage Metal Co., Box 2445, Oklahoma City, Okla.
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Thorp, Doyle (C), 2505 S. Indiana, Oklahoma City, Okla.
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Holifield, Curtis A. (C), Rt. 1, Lucedale, Miss.
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Gramer, Anthony S. (C), 1828 Green St., Philadelphia, Pa.
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Johnsen, Leonard O. (B), 3300 Disston St., Philadelphia 24, Pa.
Liberman, Russell J. (B), 112 Berkeley Rd., Glenside, Pa.
Paton, George, Jr. (B), 118 Woodland Terrace, Oaklyn, N. Y.
Scrimger, James (B), 4508 Sansom St., Apt. 314, Philadelphia 39, Pa.
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PITTSBURGH

Bowman, R. Wade (B), Arlington Apts., Pittsburgh, Pa.
Briggs, Cyril M. (B), Pittsburgh Bridge & Iron Wks., 1913 Union Bank Bldg., Pittsburgh 22, Pa.
Klingelhofer, Edw. K. (C), Pittsburgh Bridge & Iron Wks., Union Bank Bldg., Pittsburgh 22, Pa.
Klingelhofer, Louis O. (B), Pittsburgh Bridge & Iron Wks., P. O. Box 229, Rochester, Pa.
Kommel, Darwin A. (B), Pittsburgh Bridge & Iron Wks., P. O. Box 229, Rochester, Pa.
Leas, Robert K. (C), 520 Fifth Ave., Coraopolis, Pa.
Masters, P. E. (C), 323 Pine Rd., Sewickley, Pa.
McCullough, Wm. E. (C), A. O. Smith Corp., 734 Gulf Bldg., Pittsburgh, Pa.
Nelson, Claude A. (B), Engg. Dept., Westinghouse Airbrake Co., Wilmerding, Pa.
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Wolfersberger, Victor N. (B), Pittsburgh Bridge & Iron Wks., P. O. Box 229, Rochester, Pa.

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Davis, Lester L. (B), 338 N. W. Sixth Ave., Portland 9, Ore.
Faught, James E. (B), 2830 S. W. Custer, Portland, Ore.
Lottis, W. A. (B), Valley Welding Supply Co., 197 S. Commercial St., Salem, Ore.
Perry, Lee W. (B), 8041 S. E. Henry St., Portland, Ore.

PUGET SOUND

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Hossler, George L. (C), 331 Bellvue N., Seattle 2, Wash.
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Youst, Joseph H. (C), 779 Jefferson Ave., Rochester 11, N. Y.

ST. LOUIS

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Coleman, Percy L. (B), 3315 Shenandoah Ave., St. Louis 4, Mo.
Randel, O. M. (B), Independent Engg. Co., O'Fallon, Ill.

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Fry, Norman A. (B), 24 Clinton St., Springfield, Mass.
Ravening, Alfred W. (B), Alfred W. Ravening & Co., 190 Chestnut St., E. Longmeadow, Mass.

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Loosemore, Claude R. (B), Grand Rapids Boiler Wks., 234 Market Ave., S. W., Grand Rapids, Mich.
Goodrich, Earl F. (B), Goodrich Welding Mach. Co., 121 Sheldon S. E., Grand Rapids, Mich.
Miller, Robert N. (B), 534 Capital Ave., S. W., Battle Creek, Mich.

WESTERN NEW YORK

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Gardner, Paul E. (C), Buffalo Welding and Supply Co., 37 E. Ferry St., Buffalo, N. Y.
Hebeler, Edward S. (B), Hebeler Welding Co., 1005 Jefferson Ave., Buffalo, N. Y.

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Melcher, Fred J. (C), 230 McComas Ave., Wichita, Kan.
Shearer, G. F. (B), 1718 North Erie, Wichita, Kan.

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Buell, S. Nelson (C), Lukenweld, Inc., Coatesville, Pa.
Colvin, Clair R. (B), Penna. Water & Power Co., Delta 2, Pa.
Groff, John R. (C), 211 Kersey St., Coatesville, Pa.
McKinley, J. Harry (C), Safe Harbor Water Power Corp., Conestoga R. D. 2, Pa.
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Needham, Carlton (C), Lukenweld, Inc., Coatesville, Pa.
Smith, D. I. (C), Penn. Water & Power Co., Holtwood, Lancaster Co., Pa.
Tweed, Francis (C), Lukenweld, Inc., Coatesville, Pa.
Williams, Oliver W. (C), 415 Maple Ave., Coatesville, Pa.

Willraham, William S. (C), Lukenweld, Inc., Coatesville, Pa.
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Christian, John C. (B), c/o Unionmelt, Welding Department, Wainwright Ship Yard, Panama City, Florida.
Dalhoff, J. N. (C,) Ringvagen 14, Stockholm, Sweden.
Engberg, Gunnar (C), Eriksbergs Mek. Verkstads A-B, Goteborg, Sweden.

Members Reclassified

During Month of November

BOSTON

Ingersoll, F. Johnson (from D to C), 40 Hollis St., Milton 86, Mass.
Miranda, Tito (from D to C), 62 Lawn Ave., Quincy 69, Mass.
Oltsch, Howard A. (from D to C), 120 Grant St., E. Weymouth 89, Mass.

CHICAGO

Scratch, Harry E. (from C to B), 6720 S. Jeffery Ave., Chicago 49, Ill.
Sykes, Frank (from D to C), 2010 W. Armitage Ave., Chicago 47, Ill.

CINCINNATI

Kraus, Rudolph (from C to B), Stacey Bros. Gas Const. Co., Box E, Elmwood Place Sta., Cincinnati 16, Ohio.

COLUMBUS

Graham, William A. (from D to C), 113 Chittenden, Columbus, Ohio.

KANSAS CITY

Holmes, Chas N. (from D to C), Trenton, Mo.

NORTHWEST

Warmington, Thomas J. (from B to A), Wm. Bros. Boiler & Mfg. Co., Nicollet Island, Minneapolis 14, Minn.

PASCAGOULA

Guest, William R. (from C to A), c/o Ingalls Shipbldg. Corp., P. O. Box 149, Pascagoula, Miss.

PORTLAND, ORE.

Revell, G. L. (from C to B), 601 S. W. Chestnut St., Portland, Ore.

QUAD CITIES

Moore, Harold E. (from D to C), R. R. 1, Box 306, Geneseo, Ill.

SAN FRANCISCO

Evensen, Vincent J. (from D to C), c/o The Linde Air Products Co., 114 Sansome St., San Francisco 4, Calif.

NOT IN SECTION

Hancock, James H. (from C to B), 82 Shotwell St., Memphis 11, Tenn.

DIVING, CUTTING AND WELDING IN UNDERWATER SALVAGE OPERATIONS

By Frank E. Thompson, Jr.

224 Pages Illustrated Indexed $2.00

Written by an operator, designer and manufacturer of underwater salvage equipment, the President of the Thompson Engineering Company, who has been engaged in salvage operations at Pearl Harbor and other naval stations in World War II.

A "How to do" manual for men who want a well-paid, skilled, constructive, exciting wartime and postwar job.

For men learning, or preparing to learn, diving and salvage work in Navy training schools; for the crews who work topside attending the divers; for superintendents and trainers; for salvage companies; for private and Army and Navy salvage engineers.

Presents deep-sea and shallow-water diving procedure—descent, work on the bottom, ascent. Descriptions and use of diving equipment, helmets, suits, air-supply attachments, air pumps, diving stage.

Methods of decompression—stage and surface; use of recompression chamber.

Description and treatment of diving accidents and injuries; accident prevention; instructions for emergencies. Duties of crew attending the divers; methods of signaling. Surface and underwater welding and cutting methods and equipment; underwater cutting with oxy-hydrogen, oxy-acetylene, oxygen arc lance or torch and metal arc; underwater welding with electric arc—a separate chapter on each method. Decompression tables—indispensable guide to both stage and surface decompression procedure.

Published by Cornell Maritime Press, 241 West 23rd Street, New York 11, N. Y.

DR. COOLIDGE RETIRES; DR. SUITS HEADS G-E RESEARCH

Dr. C. G. Suits, assistant to the director of the research laboratory, has been elected a vice-president of General Electric and in that capacity will be in charge of the Company's research laboratory, it has been announced by President Charles E. Wilson.

At the same time it was announced that Dr. W. D. Coolidge would retire December 31 as vice-president and director of the research laboratory, a position he has held since 1940.

Dr. Coolidge, inventor of the Coolidge X-ray tube and a world-famous scientist, graduated in 1896 from the Massachusetts Institute of Technology and received his Ph.D. subsequently at Leipzig. He joined the G-E research laboratory in 1905 after a period spent in fundamental research in physics and chemistry at M.I.T. He played a leading role in the development of the modern incandescent lamp through his production of ductile tungsten. Later, when his colleague Dr. Irving Langmuir demonstrated the possibilities of a pure electron discharge in a high vacuum, Dr. Coolidge produced a radically new type of X-ray tube which has substantially superseded all previous types. Dr. Coolidge is holder of 83 patents and has been partly responsible for hundreds of others. He became assistant director of the G-E research laboratory in 1908, associate director in 1928, and director in 1932. A member of many scientific societies here and abroad, Dr. Coolidge has been awarded several medals and honors, including the Hughes, Rumford, Edison and Faraday medals.

Dr. Suits, who succeeds Dr. Coolidge as head of research, is one of the youngest of the country's prominent scientists, graduating from the University of Wisconsin in 1927 and becoming a member of the G-E laboratory staff in 1930. He is widely known for his research in high-temperature arcs. During the war he has devoted a major portion of his time to the direction of war research under the auspices of the Office of Scientific Research and Development, and as chief of Division 15 of the National Defense Research Committee has supervised the radio co-ordination activities of a group of scientists. He was made assistant to the director of the G-E research laboratory in 1940.

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

PICKER X-RAY CABINET

The Picker Rayproof Industrial X-Ray Inspection Cabinet manufactured by Picker X-Ray Corp., 300 Fourth Ave., New York, offers an efficient means for continuous X-ray examination of parts on a production schedule. No time is lost in positioning or removing the parts for actual X-raying since setups are made and removed outside the actual exposure chamber. The cabinet is so designed that on completion of the exposure period, a tray, bearing the radiographed parts, is ejected simultaneously with the entry of a net setup, the whole system moving on rollers. The central exposure chamber is equipped with rayproof sliding doors so that during exposure, while new parts are being loaded or already exposed parts unloaded, the operator is completely protected from all radiation.

NEW PHOTOMETER FOR MEASURING LIGHT TRANSMISSION

A new transmission photometer for measuring accurately the amount of light transmitted through very small areas of spectrographic plates, has been announced by the Special Products Division of the General Electric Co., Schenectady, N. Y. The new photometer is desirable for use wherever spectrographic analysis is employed, such as in the metal fields, and also for microcolorimetric and microchemical analyses and for measuring light transmission through solutions.

Requiring a constant power supply of 6 v., a. c. or d. c., with an approximate capacity of 30 amp., the photometer consists essentially of a light source, an optical system, a galvanometer, a light-sensitive cell, and a mechanical stage for accommodating the plate. This stage, which has a three-point, ball-bearing suspension, is movable in three directions, thus providing smooth, precise control of the position of the plate. Control knobs conveniently mounted on the front of the instrument facilitate focal adjustment and control of the several diaphragms and filters in the optical system which govern the intensity of the light and heat reaching the light-sensitive cell and the plate. Mounted in an attractive, sturdily constructed case, the instrument is especially easy to operate, since all adjustments can be made and seen readily from a single position.

"RESISTANCE WELDING AT WORK"

An unusual, comprehensive and informative piece of literature on resistance welding has just been made available by Progressive Welder Co., 3050 E. Outer Drive, Detroit 12, Mich., leading developers and manufacturers of resistance welding equipment. Entitled "Resistance Welding at Work," (Bulletin WP-44) it is in the form of a 60-page two-color 11 x 8½ in. book containing scores of illustrated examples of resistance welding applications.

The book is a striking commentary on the tremendous increase in scope and application of resistance welding during the war and immediate prewar years. It is designed primarily as a guide to the wide variety of uses to which resistance welding adapts itself—whether it be single spot or multiple spot, seam or flash, butt or projection welding—and whether the work is to be brought to the machine or the equipment brought to the work in fixtures.

In this book there is an answer by examples of "how it is being done" to practically every general type of resistance welding problem encountered and equipment required either in war production or in postwar retooling for output of modernized peacetime goods. To facilitate use of the book the material has been arranged under five general headings in such a manner that the answer to a given general problem can be quickly and easily located. The divisions deal with portable gun welding (for work assembled in fixtures); stationary spot welding, single and multiple (where work can be brought to the machine); seam welding, either in machines or in fixtures. There is also a section devoted to special uses to which resistance welding equipment can be put as well as a section illustrating, by examples, possibilities in fixture design, large or small.

BRAZERS THAT GO TO THE WORK

Brazing is an old but still not too generally used method of joining members of copper, brass, bronze or various alloys. One handicap has been the lack of brazing apparatus that can be readily taken to the job, as in shipyards, railroad shops, etc. For the production lines of factories, the well-developed brazing furnaces are in much demand but there has been a need for portable units for joining wire cables, strap connectors, pipe, etc. This need is met by a self-contained family of brazing sets that require only a connection to a 220-volt power source. These sets consist essentially of a transformer for providing high currents at low voltage, suitable voltage selectors, controls and carbon-tipped tongs that can be clamped over the pieces to be joined. The high currents flowing through the carbons bring them to incandescence, quickly bringing the material to brazing temperatures, which are from 1200 to 1500° F.

Three sizes, 5, 10 and 20 kva., comprise this group of mobile brazing elements The 5- and the 10-kva. units are air cooled The 20-kva. unit is fan cooled and has a self-contained water cooling and recirculating system used to cool the brazing cables and tongs. This cooling system permits the use of a small-size portable unit for medium brazing work. The smallest unit weighs but 30 lb., the middle-size one, 100 lb. and the 20 kva., 250 lb. The corresponding secondary currents are 625, 833 and 1667 amp. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

TRANSPORT WITH 4-WAY FLOOR PLATE DECK

The application of 4-Way Floor Plate to the standard Turner Transport Chassis increases considerably the various uses of this unit of the Turner System of Materials Handling.

The floor plate is welded flush with the top of the chassis on the angles of the frame. It is reinforced on the under side by two heavy angles. The "non-skid" feature keeps metal parts from "walking" off easily when the Transport is in motion. Further, the embossments provide point contact with hot materials which allows some air space between them and the steel deck. Warping of the steel deck is thereby eliminated.

The Transport is the foundational unit upon which the entire Turner System is based. It can be moved in restricted space by the hand Jimmy, power lift truck, crane, tractor or conveyor. With Turner Piling Stakes, the load may be expanded vertically to any practical height.

Steel or wooden bin sections and section trays also interlock one on another on top of this Transport, thus making always available bins as high or low as the particular job requires.

For further information write to Factory Service Col., 4615 North 21st St., Milwaukee 9, Wis.

CARRIER FOR WELDING ELECTRODES

Preventing scrapping of welding electrodes due to cracked and chipped flux coating (caused by current practice of having them strewn over the floor), this two-purpose case is designed to carry a supply of electrodes suspended from welder's belt. Extra division is provided for carrying an Atlas Weld Cleaning tool.

Time saved in having both electrodes and chipping hammer constantly at the welder's hand will quickly repay the original cost.

Long life is assured by heavy harness leather construction, riveted for permanence. Broad loop is provided for attaching to welder's belt. Capacity is 8 to 10 lb. of electrodes. Height of case is 12 in.; diameter $3^1/_2$ in.

Made by Atlas Welding Accessories Co., 14824 Wyoming Ave., Detroit 21, Mich.

A SPOTLIGHT FOR WELDING

An arc welder before he strikes his arc is as blind as the traditional bat. Objects under normal illumination cannot be distinguished through the smoked glass window of his mask although the arc is so intense as to provide ample light after welding begins.

A new spotlight at the Westinghouse Research Laboratories takes out the guesswork of striking the arc in the proper place. It casts on the work area a light twice as bright as the brighest sunlight on a seashore in summertime. This light is intense enough for the welder to see the spot to be welded even through his mask filter. A footswitch makes it possible to turn the light on for an instant to locate the spot where the arc should be struck.

This bright beam of light, furthermore, is produced without creating much heat—which is an important point to a welder working in a small welding booth in the summertime. By using a lamp of the sealed-beam type, 10,000 foot-candles is thrown on the work 3 ft. from the lamp with an expenditure of only 32 watts, less than one third that of a good reading lamp at home. It is expected that two lamps will be used to provide an overlapping pattern, totaling 20,000 foot-candles. Because the light can be concentrated much better from a low-voltage lamp, the 110-v. supply is reduced to 6 to 8 v. by a small transformer built into the back of the reflector. A shield with blackened interior extends some distance in front of the lamp to prevent stray light from causing glare to a neighboring welder.

These lamps can be clamped to a simple upright or arranged on a horizontal bar. Simple horizontal and vertical adjustments provide accurate placement of the beam spot. Still a laboratory development, the new lamp is not commercially available.

PROTECTIVE EQUIPMENT

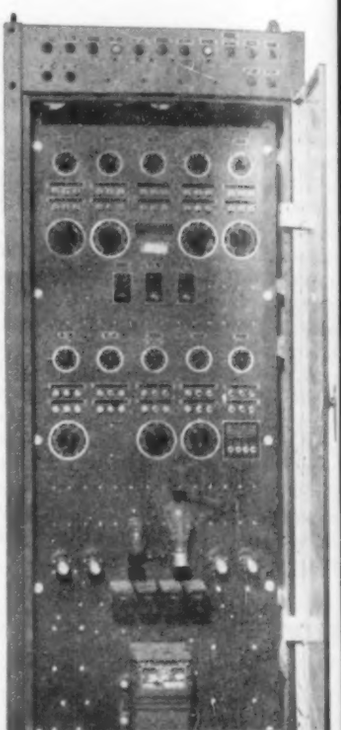
Ankle and foot protection against acids, alkalis, oils, solvents and greases is provided by a new spat announced by the American Optical Co., Southbridge, Mass.

The spat is made from a coated fabric which gives the same protection as rubber but is much lighter in weight and extremely flexible.

Three snap fasteners at the top and two at the bottom make the spat easy to put on and adjust, and assure quick removal. An elastic strap fits under the instep. Large flare assures over-all protection of instep. It is neat, snug fitting and comfortable. Pants may be worn over the spat or tucked inside.

WELD AND SEQUENCE TIMER

A new weld and sequence timer for providing the various time and current adjustments necessary for welding heavy sections of air-hardenable steels, has been announced by the Industrial Control Division of the General Electric Co. Although this timer, known as Type CR7503-F1D, is especially designed for use with a G-E ignitron contactor and a heat control panel, it can also be used in combination with most G-E spot-welding controls which include the phase-shift method of heat control.



Front View Showing Door Open, and Showing Indicating Lights, Time and Current Adjustments, Pressure Period Adjustment and Tubes

Operating from 230/460/575 v., 60 cycles, the control adjusts the time of current flow and its magnitude for preheating, welding, grain refinement and tempering. Other adjustments control the time for chilling the weld nugget following the weld and grain refinement periods. For variations in control voltage of +10 to −20%, consistency of timing will be within plus or minus one-half of 1% of the time setting. However, it is recommended that a G-E current-regulating compensator be used with this combination to correct for variations in welding current caused by line voltage variation or the introduction of magnetic materials into the throat of the welding machine.

This control consists of nine time intervals, seven independent heat adjusters, two pressure interval timers, one squeeze timer, one hold timer and provisions for a two-stage foot switch, all housed in a steel enclosure. Control adjustments are easily accessible on the front of the panel and each timer has a separate time adjustment and an indicating light, which

gives a quick indication of which timer is in operation. The heat control potentiometers have large graduated dials which enable accurate heat settings. A minimum number of tubes (6) are used to give the multiplicity of operations required.

ELECTRODE HOLDER

After long use and development in its own shops, Pacific Engineering Corp. is now marketing the Mor-Weld, a revolutionary, new type of electrode holder.

One of its innovations is the heat-resisting, "Everlast" plastic jaw cover. This new jaw cover, in competitive field tests and later in actual operation, outlasted the conventional types by giving 20 to 30 times longer service. This longer

life eliminates the necessity for constant changing and servicing of jaw covers, as well as handle covers. An additional economizer of time and money is Mor-Weld's flexibility which enables the welding rod to be consumed down to a mere stub without the necessity of bending. Grip holds all rod sizes.

In addition, the quick-change, lever-action jaws can be replaced in less than a minute without tools. All parts are quickly interchangeable because there are no pins or bolts—which allows for fast servicing and cleaning.

Manufacturer seeks distributors for this new, wanted tool. Write to Pacific Engineering Corp., 3123 San Fernando Road, Los Angeles 41, Calif.

NEW ELECTRONIC TIMER GIVES UNIFORM X-RAY EXPOSURES

A photoelectric X-ray timing device now enables radiologists and technicians to obtain uniformly dense photofluorographic exposures with an over-all increase in operating efficiency of 100%. The electronic timer, developed by the Westinghouse Electric and Manufacturing Co., times each exposure properly, quickly and automatically. The timer in effect, measures the light leaving the fluorescent screen on which the X-rays cast the object image. When sufficient light has left the screen for satisfactory film exposure, the photoelectric tube which scans the screen actuates a relay, opening the X-ray circuit and terminating the exposure.

Although first used in medical radiography for mass chest surveys on miniature roll films, the development promises to be generally useful and will include industrial X-ray analysis. Whether similar objects, such as castings, are moving rapidly on a conveyor or whether a variety of irregular objects must be X-rayed, the electronic timer will provide uniform exposures quickly and efficiently.

Use of the photoelectric cell to control exposures in photofluorography was first undertaken by Dr. Paul C. Hodges and Dr. Russel E. Morgan at the University of Chicago. The electronic timer takes advantage of the nature of the photoelectric tube whose output is proportional to the light striking the cathode.

The heart of the Westinghouse Phototimer is the so-called phototube camera consisting of a lens which scans the fluorescent screen, a photoelectric multiplier tube and a condenser—thyratron—relay system. The phototube camera is mounted beneath the photofluorographic hood and "sees" the object image on the screen which is "seen" by the photographic camera at the apex of the hood. Light from the screen initiates a small current in the photoelectric tube which is greatly amplified. The output current charges the condenser until the proper ionization voltage is reached when the thyratron fires actuating the relay which opens the X-ray circuit and terminates the exposure. Proper choice and design of circuit constants enable the timer to maintain the correct exposure factor for uniformly dense film exposures.

Two factors account for the initial development of the timer for chest photofluorography: (1) the importance of mass chest surveys in controlling civilian tuberculosis and (2) the demands of the Armed Forces in examining large numbers of inducted men. "Miniature photofluorography—taking small-film photographs of full-scale images created on a fluoroscopic screen by the action of X-rays—is the only practical and economic way to conduct the mass chest surveys necessary to detect the presence and prevalence of tuberculosis in the whole population," explained A. P. Craig, manager of the X-Ray Division of the Westinghouse Co.

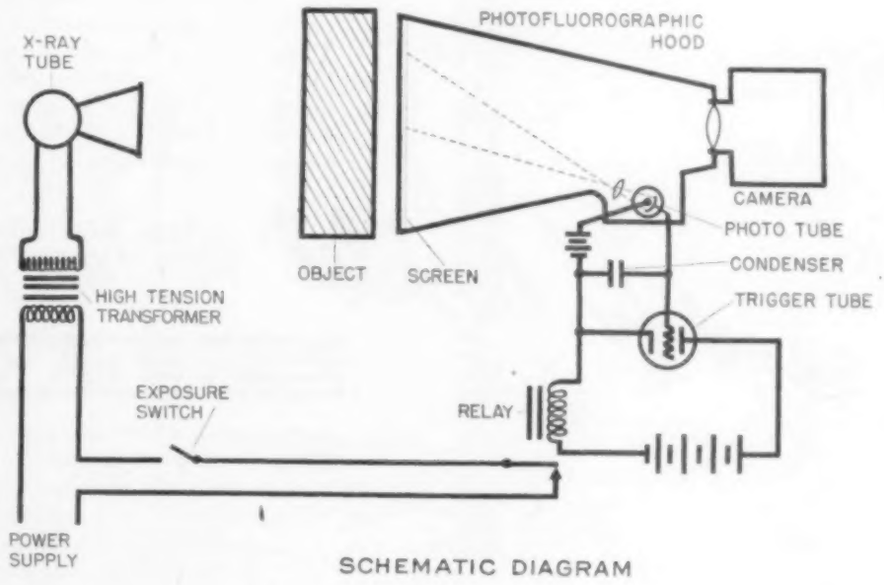
Until now, a major difficulty barring full utilization of the analytic capabilities of X-ray has been the lack of automatic exposure controls. The use of the new phototimer, according to Henry D. Moreland, manager of engineering of the Westinghouse X-Ray Division, automatically assures a correct X-ray exposure, enabling the technician not only to double the number of exposures formerly made but to achieve better and more useful results as well.

"In order to evaluate accurately X-ray pictures," Mr. Moreland said, "it is important that the exposures be uniform in density and in what photographers call contrast—the sharpness of difference between the light and the dark areas."

X-rayed objects may vary not only in size and thickness but even in the degree to which X-rays are transmitted. These variables make it difficult to obtain uniform film exposures. Expert technicians develop considerable skill in estimating X-ray penetration, but such evaluations and measurements are time-consuming and at best are only approximations. Therefore, even the best technician can only attain comparative uniformity of film exposures. The new Westinghouse Phototimer is a device to turn the speed and accurate perception of electronics to this test."

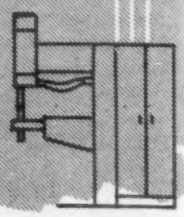
BOUND VOLUME JOURNAL

The AMERICAN WELDING SOCIETY has made arrangements for members who wish to have their Journals for 1944 bound in attractive, black cloth covers, to do so by sending copies of the twelve issues to Russell-Rutter Company, Thirty-Third Street and Eighth Avenue, New York, N. Y., Att. Mr. Russell Lauben, Jr. A special reduced rate has been arranged at $2.50 per volume providing the issues of the JOURNAL are sent to the binder on or before March 1, 1945. Journals received after this date cannot be bound at this reduced rate. The bill for the binding and return postage will be sent direct from the Society's office.



SCHEMATIC DIAGRAM

"THREE-PHASE" resistance welding

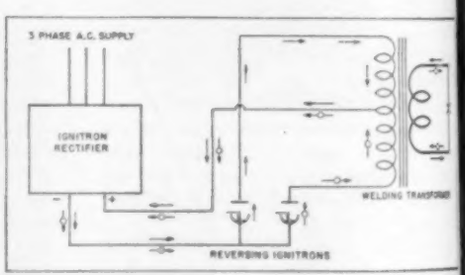


what it means

Spot, seam or flash welding steel in heavy gauges can now be accomplished on a balanced three phase load. This revolutionary achievement in power efficiency overcomes many limitations encountered with a.c. single phase welders. These are: disturbance to the usual three-phase supply by the unbalanced load, the heavy reactive load which results in low power factor, and the high power demand caused by secondary resistance. The Sciaky "THREE-PHASE" system *reduces cost of power installation and cost of operation* by providing:

1. ***A balanced three-phase load***
2. ***Operation at near unity power factor (less KVA)***
3. ***Decreased actual power demand (less KW)***

how it operates



As shown in the schematic diagram, all three phases of the a.c. line current are converted by an ignitron type rectifier to d.c. The welding transformer is of the standard single-phase type, but has a center-tapped primary. The d.c. current is fed to the primary through a system of two ignitron tubes which fire alternately and allow the current to flow through only one winding at a time. Thus, while the direction of the current supplied by the rectifier is always the same, since it flows in only one winding at a time during successive impulses, *it will flow in opposite directions in the primary.* Therefore, the induced welding current in the secondary is a continuous alternating impulse of low frequency . . . *of ideal wave shape and magnitude.*

send for booklet

Bulletin 204-A describing fully the operation of the Sciaky "THREE PHASE" will be gladly sent on request.

SCIAKY BROS

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